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THE WESTINGHOUSE-PARSONS STEAM TURBINE.

Remarkable Steam Economy With Wide Range of Load.

Power House of the Westinghouse Air Brake Co.

The Westinghouse Machine Co., after a few years of experimental work, have established the steam turbine in this country upon a basis which will surprise those who have not been watching it.

It has recently been installed in the power plant of the Westinghouse Air Brake Co. at Wilmerding, and in a short time it will be depended upon entirely for the motive power and lighting of these works. This installation is in itself an expression of confidence in these machines, the effect of which will not be lost.

In 1896 the patent rights in the Parsons Steam Turbine for the United States were acquired by the Westinghouse Machine Co., and this concern has been engaged upon a development which has resulted in marked improvements over the original machines in England. The assistance of Mr. Francis Hodgkinson, an engineer who was identified with the development of the Parsons Turbine in England, was secured, and he is now in charge of the turbine department of this company at Pittsburgh. Work is now well advanced on a 2,500 h. p. turbine, Fig. 7, for the United Light & Power Co., of New York. It will be the largest unit of this kind ever attempted, and will run at 1,200 revolutions per minute under a steam pressure of 150 lbs. The spindle of this machine, complete with its vanes, weighs 28,000 lbs. The largest diameter of the spindle is 6 ft. and while this is a colossal turbine, it is a small engine for such power capacity. The capacity of the direct connected generator will be 1,500 kw. and the ultimate capacity of the turbine about 3,000 h. p.

The steam turbine is, in a sense, a return to the principles of the earliest steam engine, in which the energy of the steam was transformed into work by making use of the impact and reaction due to its velocity. There is no loss from condensation and re-evaporation, or loss by reason of the same passages being used alternately for live and exhaust steam, as is the case with reciprocating engines. The work is taken out of the steam progressively, and the temperature falls gradually and continuously from the admission to the condenser. In these features it has advantages over other steam engines. The continuous action, absence of dead centers and the consequent mechanical complications, together with the avoidance of suddenly applied and instantly reversed stresses, are advantages the full purport of which is not yet fully appreciated. The economy of the turbine and its wide range of economical load will be mentioned later in connection with Fig. 6.

At the Westinghouse Air Brake Co.'s shops, three 500 h. p. turbines are direct connected to 300 kw. generators and are furnishing power for driving and lighting the entire plant by means of a newly installed electrical distribution system, which we shall describe. The turbines are comfortably located on a floor space 20 x 25 ft., the bed plate of each machine measures 16 ft. 7 in. x 4 ft. 3 in., and the whole plant producing 1,500 h. p. and including three turbo-generators, two 10 h. p. exciter engines and generators, two pairs of condensers and air pumps, and the switchboard occupies a space of 29 x 36 ft. The turbines are designed for condensing the exhaust and for this purpose a novel air pump design was developed. This consists of a combination of a pair of jet condensers and compound air pumps, in which the water and air are handled in separate cylinders. The condenser pumps are operated by a 50 h. p. belted motor, this being the cheapest and most convenient method in this case. The vacuum is often as high as 28 ins., while the average barometer is 29.25 in Pittsburg. The delivery water is only a fraction of a degree different in temperature from that of the steam in the condenser. The operation of these engines, considered thermally, is most impressive; for example, the temperature of the boiler steam entering the turbines is about 350 degrees, and yet at a point about 4 ft. from where the steam enters the cylinder, the exhaust pipe is cool enough to hold ones hand upon very comfortably. This is a revelation to those who notice it for the first time. The exhaust temperature at the time of the writer's visit was 102 degrees, while the temperature of the discharge water from the condenser was 101 degrees. This is a remarkable exhibition of the transformation of heat into work. There cannot be much condensation, or the close fitting parts would not operate so smoothly at these high speeds.

The turbines are of the multiple expansion type, running at 3,600 rev. per minute, with 125 lbs. boiler pressure. There is no gearing for reducing the speed, and this equipment is in marked contrast with the DeLaval system, which is characterized by some 13,000 revolutions in a turbine of about this capacity, reduced by gearing to 1,050 rev. of the generator and working at 150 atmospheres steam pressure. The DeLaval system makes use of flexible shafts, which break, gearing which wears out and other unpractical conditions, which are out of the question outside of the laboratory of the inventor.

In the turbines which we are describing a single bed plate carries a unit of one turbine and its generator. A cast iron base supports a cylinder of varying internal diameters, in the interior of which numerous rows of guide blades or curved vanes are secured. The exterior contour in the engraving gives an idea of the construction. A shaft carrying drums of correspondingly varying diameters, with similar rows of blades secured radially and spaced to fit between the stationary rows, constitutes the rotary part, which corresponds to the wheel of the turbine water wheel. The shape of these blades represents a great deal of study and experiment. The stationary rows of blades serve to guide the steam in the proper direction for doing work upon the movable ones. The steam enters the small end of the cylinder and in expanding through the first set of guide blades, its energy is transformed into velocity, and in impinging against the next set, which are on the spindle, it gives up nearly all of its velocity. In expanding through the moving blades the steam again attains a velocity which by reacting upon the blades gives up energy to become work. Each succeeding row of blades increases in size, corresponding to the increased volume of the steam. The cylinders are di-

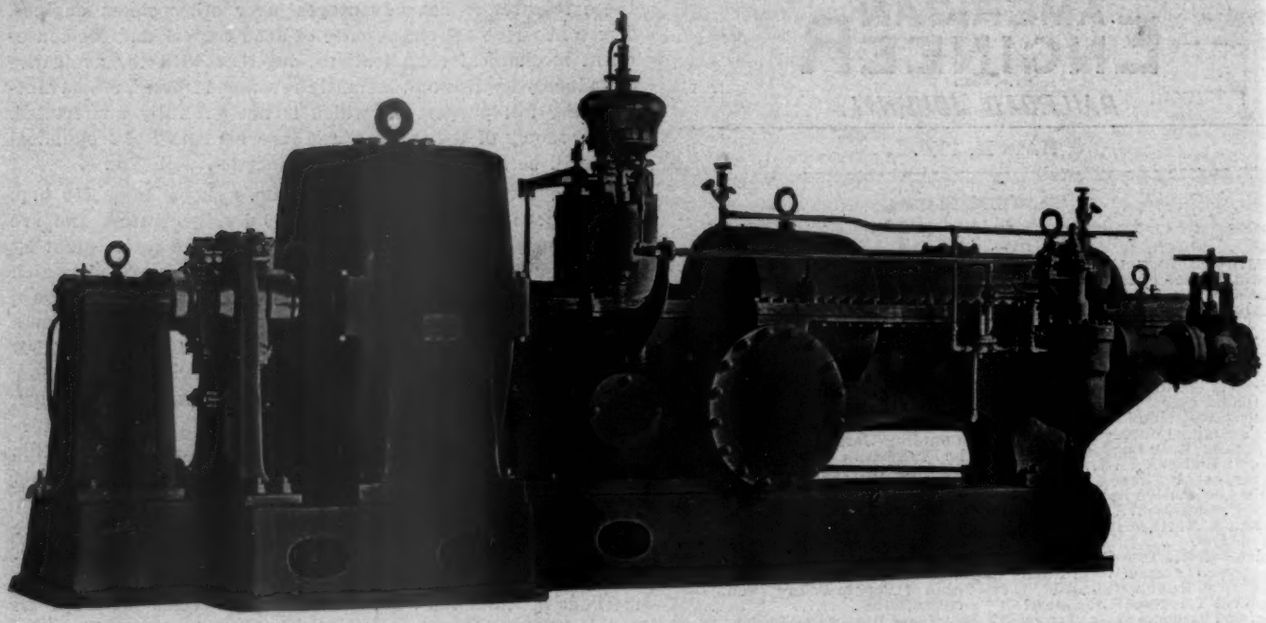


Fig. 1.—Side View of Turbine and Generator Showing Governor Connections to the Steam Valve.

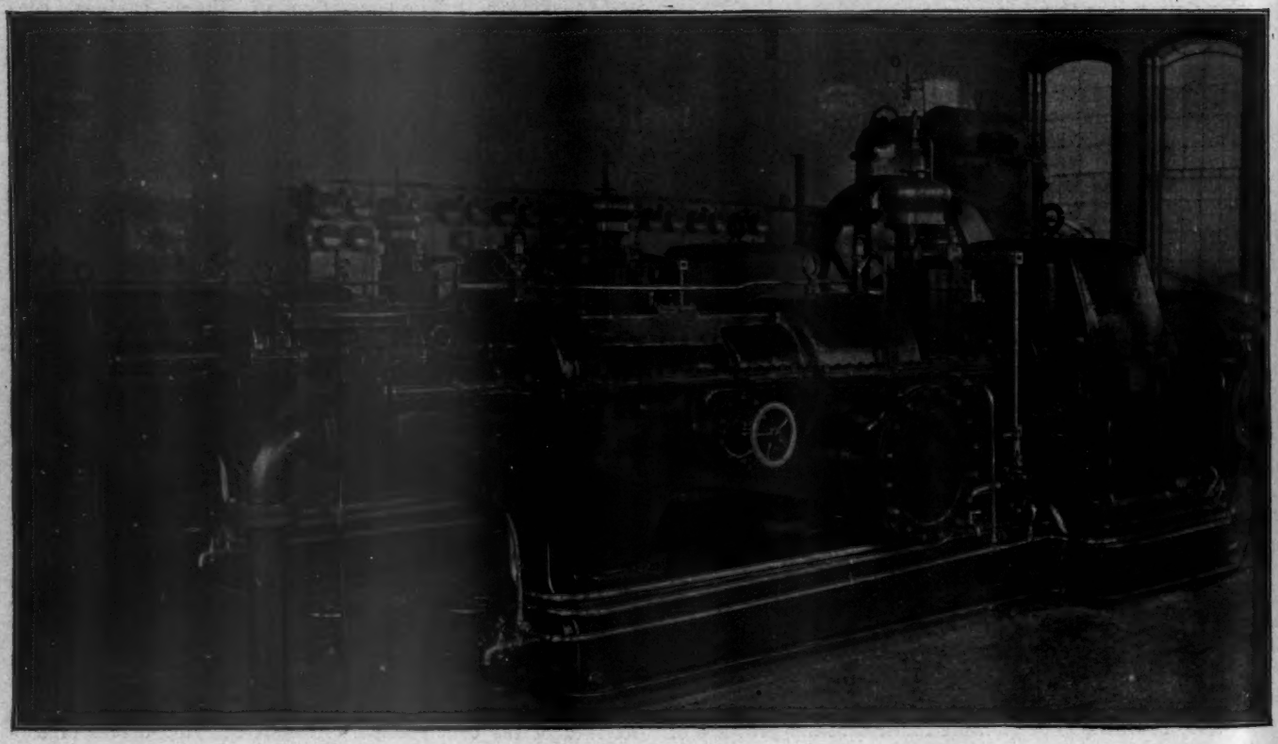


Fig. 2.—Rear View of Three Turbine Units.

Westinghouse-Parsons Steam Turbine at the Works of The Westinghouse Air Brake Co.

vided into three steps, in each of which there are several grades of expansion. The total expansion ratio is about 1 to 96.

The high speeds necessitate careful balancing and this extends also to the armature of the generator. This has been accomplished so well that no foundation is required (even for the large machine shown in Fig. 7) except a brick pier to support so much dead weight. There are no holding down bolts. Lubrication in this case is most important, an oil pump, shown in Fig. 5, driven by a worm mounted on the sleeve coupling between the turbine and the generator, circulates oil into all the bearings under a light pressure and a cooling system is provided in order to cool the oil on account of the heat absorbed from the steam. The balancing is of course not absolutely perfect, and the bearings are made to provide for a slight motion of the shaft. The bearings are made with concentric tubes of brass surrounding the journal, and are put together with easy fits and spaces for oil between them. This forms a self-centering cushion, which has a tendency to reduce the vibrations of the shaft. The tubes show no signs of wear, because of the films of oil between them, the oil forming the real bearing. The

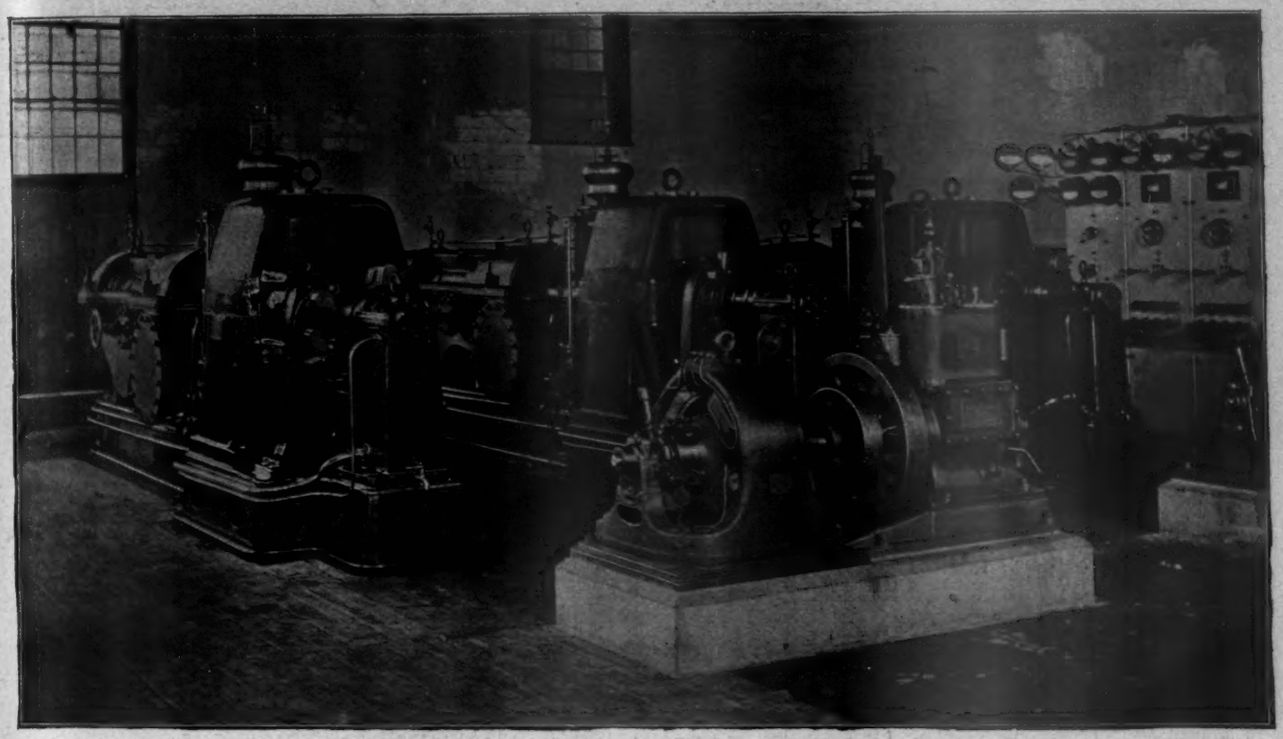


Fig. 3.—End View of Three Units, Showing Comparison with 10 Horse Power Exciter Unit.

Fig. 4.—View in Power Station Showing Generators, Exciter Units and Switchboard.
Westinghouse-Parsons Steam Turbine at the Works of The Westinghouse Air Brake Co.

shaft is not rigidly confined, as in the ordinary tight-fitting bearing, and this slight latitude of motion of the shaft is an important element in the working of this machine. This motion takes care of the gyration which the most perfect balancing that is practicable does not eliminate.

To counteract the end thrust on the spindle, due to the impact of the steam on the blades, the shaft is held in equilibrium by means of three balancing discs at the steam end of the spindle contained in the turbine casing and marked in Fig. 5. These are made steam tight with the cylinder, and the diameter of each disc is made equal to the mean diameter of the corresponding drum carrying the blades. These disc chambers are connected by cores through the cylinder casting, with the spaces occupied by the corresponding drums. In this way the shaft floats endwise as it may, but it has no thrust. The steam cylinder has a by-pass valve, Fig. 5, which admits steam from a cored passage leading from the entrance port to the second drum. This may be used to increase the power of the machine when a heavy overload is to be carried (even to 60% overload), or it may be used to increase the power in case the

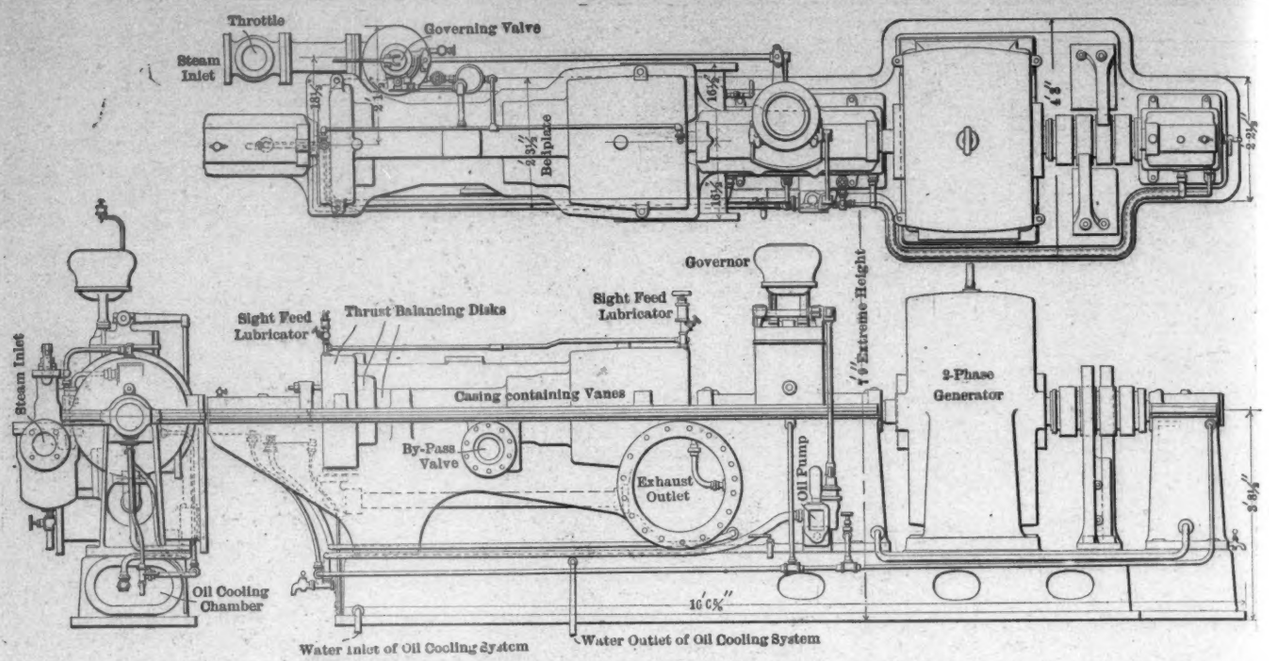


Fig. 5.—300 Kw. Unit as Erected at Westinghouse Air Brake Works.

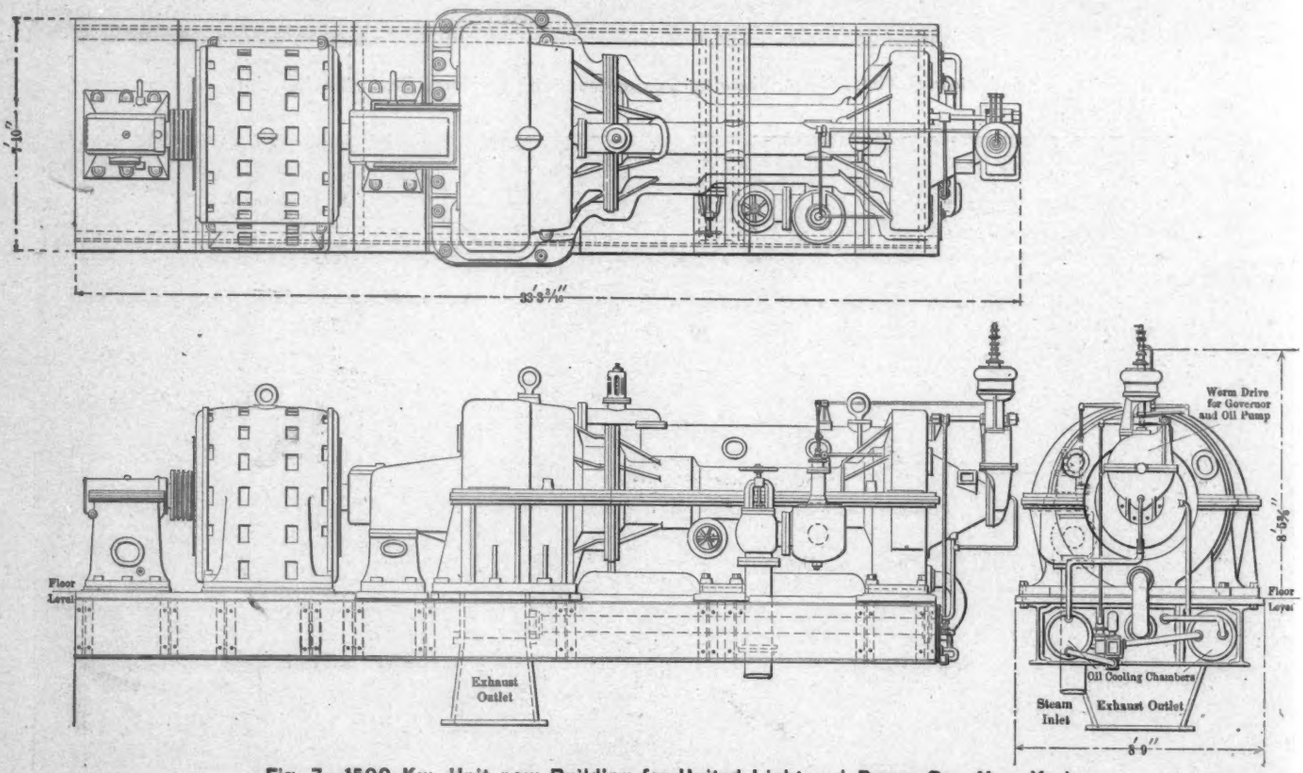


Fig. 7.—1500 Kw. Unit now Building for United Light and Power Co., New York.

condenser is inoperative, for any reason. This increases power at the expense of efficiency, however.

This is the first time that direct connected alternating current generators have been successfully driven by turbines for multiple connection. The speed regulation is beautiful, and it is accomplished without the least stress, jerk or strain upon anything connected with the machinery. The governor, which is of the fly-ball type, controls the duration of the intermittent admission of steam. Lever and shaft connections from an eccentric, driven by a worm on the main shaft (under the governor) already referred to, operate a little piston valve, which controls the larger main admission valve, which is also of the piston type and located as shown in Fig. 5. The central position of the governor gives continuous admission and this is the full load condition. The governor, by raising or lowering the fulcrum of the lever, but without changing the leverage, changes the plane of motion without changing the stroke of the little piston valve and thereby determines the duration of the opening of the main valve. At full load the valve is open all the time, and at very light loads it is closed most of the time. The intermitent admission is to insure working with high pressure steam, whatever the load, and to prevent the losses of wire drawing.

The governors are extremely sensitive, and may be adjusted to run within a small fraction of 1% variation between no load and full load. But in this particular case, on account of the

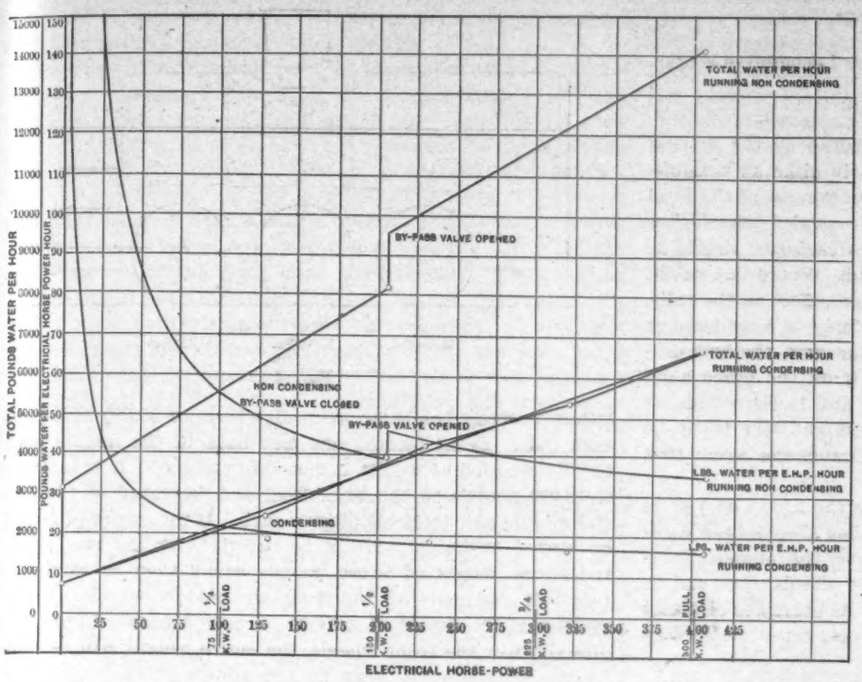

TOTAL WATER PER HOUR RUNNING NON CONDENSING
BY-PASS VALVE OPENED
TOTAL WATER PER HOUR RUNNING CONDENSING
NON CONDENSING BY-PASS VALVE CLOSED
BY-PASS VALVE OPENED
LBS. WATER PER E.H.P. HOUR RUNNING NON CONDENSING
CONDENSING
LBS. WATER PER E.H.P. HOUR RUNNING CONDENSING
TOTAL POUNDS WATER PER HOUR
POUNDS WATER PER ELECTRICAL HORSE POWER HOUR
ELECTRICIAL HORSE-POWER
¼ LOAD
½ LOAD
¾ LOAD
FULL LOAD

Fig. 6.—Test of 300 Kw. Unit, Showing Remarkable Steam Economy Over Wide Range of Load.

generators having to run in multiple, it is desirable to have a considerably greater variation, in order that each generator may take its proper share of the load. The speed of the turbines and the inertia of the rotating part are so great, while the friction is so small, that the turbine will continue running for twenty minutes after steam is shut off. Under these conditions, change of speed during one revolution is absolutely negligible. There is an adjustment provided on the governor by means of which the speed may be varied within wide limits, while the turbines are running. This enables the generators to be brought into synchronism, and the loads divided with the greatest ease.

The generators, made by the Westinghouse Electric & Mfg. Co., are of the bi-polar type, giving a two-phase alternating current of 440 volts with 7,200 alternations per minute, and having a capacity of 300 kw. each. They appear absurdly small for such capacities until the high speed is considered. Very elaborate tests were made at the works of the builders, resulting in the very remarkable curves of efficiency shown by the diagram, Fig. 6. The long horizontal portion of the steam consumption line is wonderful when one considers that this machine of only 500 h. p. will work on any load from about one-quarter load up to a large overload, with greater economy than most of the highest grades of reciprocating engines of many times this capacity, even when taken at their best. The following condensed statement shows the economy:

Full load, 13.4 lbs. steam per electrical h. p. per hour.
¾ " 17 " " " " "
½ " 18.2 " " " " "
¼ " 22 " " " " "
Running light, 750 lbs. steam per hour.

We feel perfectly safe in saying that these results have never been approached before. It is impossible to measure the indicated and probably also the brake h. p. of these turbines, but it is estimated that they are working, at full load, on 13.2 lbs. of steam per indicated h. p. per hour, using this term in its understood sense. The turbine has, therefore, scored a remarkable triumph in this its first appearance in this country, in a place of responsibility in driving an important plant.

It should be understood that these particular turbines have been designed to give their best results when running condensing, hence the comparatively inferior results when running non-condensing, which are shown in the economy curves. A turbine designed essentially for non-condensing would give relatively as good results as these turbines running condensing. The diagram also shows the effect of opening the by-pass valve.

The half-tone engravings, Figs. 1 to 4, inclusive, were made from photographs taken in the power station. Fig. 1 shows a side view of one of the turbine sets. One of the large exhaust openings is seen in this view, covered by a plate. There are two such openings, one on each side of the machine. This view also shows the governor connection to the admission or governing valve and the throttle valve appears at the extreme right. A rear view of the three turbines is given in Fig. 2. The generators are at the right and the switchboard appears over the turbine. A comparison between the size of the 10 h. p. exciter unit and the turbines may be made in Fig. 3. There are two of these exciter units driven by Westinghouse engines. A view of the generator ends of the turbine units is given in Fig. 4, which also shows the switchboard.

The shops of the air brake company are now equipped with a large number of two-phase induction motors, made by the Westinghouse Electric & Mfg. Co., and the entire installation has been made with commendable thoroughness, which includes the arrangement and appointments of the power station. The wires and steam pipes are all under the floor level. This distribution system will be made the subject of another article.

We are indebted to Mr. E. E. Keller, Vice-President and General Manager of the Westinghouse Machine Co., for the photographs and drawings accompanying this description.

The White Pass & Yukon Railway, the interesting new line in Alaska, has 20 miles now in operation, 16 of which are on a grade of very nearly 4 per cent. In spite of the difficulties which this hill causes, the operation has been free from serious accidents since its opening a year ago last July. During the month of September last, nearly 1,000,000 pounds of freight were hauled, and the average number of cars available was but 50.

A severe test of cast steel bolsters, made by the American Steel Foundry Co., of St. Louis, described in a recent issue of the "Railway Age," is noteworthy. In a rear-end collision on the Chicago & Alton the engine of the second train turned the caboose of the leading train aside, and in the mix-up this locomotive was carried up on top of a loaded coal car of 80,000 pounds capacity and was towed to the shops on the car. The weight of the engine was about 50 tons, and the total load of the car including the coal was about 90 tons, this weight, of course, came upon the bolsters, and they met the severe test without breaking down or being damaged in any way. This accident substantiates the strong claims made for these bolsters in an unmistakable way.

The three new battleship designs, the "Georgia," "New Jersey" and "Pennsylvania," which have been agreed upon by the Naval Board of Construction, will be superior in speed and fighting power to any warships yet built or planned by any other nation. Their displacement will be about 14,000 tons, speed 19 knots or more, bunker capacity 2,000 tons, and steaming radius 7,000 miles, which is sufficient to cross the Atlantic and come back. There will be two 12-inch and two 8-inch long guns for smokeless powder in each of two (fore and aft) superimposed turrets, and also twelve 6-inch rapid-fires. The armor is to be the "Krupp" and the cost will be about $7,000,000 each when fully equipped.

LOCOMOTIVE DESIGN.*

By F. J. Cole, Mechanical Engineer Rogers Locomotive Works.

Equalization of Weight.

It is very desirable that the weights borne by the driving wheels of a locomotive should be as nearly alike as possible, and that each wheel should bear its due proportion of the total load. If an engine with three pairs of coupled wheels has 90,000 pounds on the drivers, the weight on each pair should be 30,000 pounds, or one-third of the total load. Where the weight is thus uniformly distributed the destructive effect on the rails, bridges, etc., for any given class of engine may be considered as most favorable, and apart from the size and type, the best possible distribution that could be made. If on the other hand the weight was 60,000 pounds on one pair and 15,000 pounds on each of the other pairs, the arrangement might very justly be considered the most unfavorable and probably the worst that could be made.

The equal distribution of weight among the 2, 3, 4 or 5 pairs of drivers varying according to the type, has always been carefully considered in locomotive design, and the numerous instances of overloads on some one pair of wheels, that can be seen in existing engines should be viewed as examples of faulty design and not as inherent defects in certain types which cannot be remedied.

If a beam (Fig. 1) be supported at both ends and uniformly

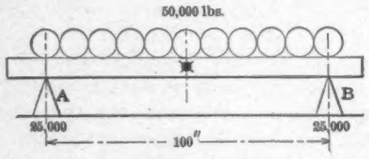


Fig. 1

loaded with a weight of 50,000 pounds, including the beam, it is evident that the supports A and B will each bear one-half the total weight or 25,000 pounds. If, however, the support A be moved toward the center, as in Fig 2, one-quarter of the original distance, so that the centers of support are 75 inches apart instead of 100 inches, the load on A is increased to 33,334 pounds, and decreased on B to 16,666 pounds. To find out the weight on A or B for any position of A,

Let W = total load.

W_1 = load on support A.

W_2 = load on support B.

C = distance between supports.

D = distance from A to center of gravity.

Then $$D = \frac{W_2 \times C}{W}.$$

$$W_2 = \frac{D \times W}{C}.$$

If an engine had no equalizers each pair of wheels would

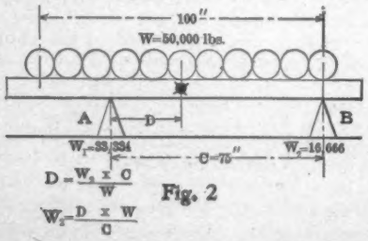


Fig. 2

carry that proportion of the entire load which is due to the position of the longitudinal center of gravity of the structure carried by the driving springs. The individual wheel loads would also vary according to the spacing of the wheels and the amount the load overhung the front or back wheels. In Fig. 3 is shown an engine without equalizers, the center of gravity of the boiler and attachment being at A. Had it been directly over the middle wheel the total weight would be equally distributed among the three pairs of wheels or 20,000 pounds for each pair. Being located one foot back of the middle wheel the distribution of weight is materially altered. It is increased to 28,000 pounds on the rear wheel and decreased on the front and middle pair to 16,000 pounds each. If the center of gravity be moved backward until it is directly over the rear wheels the entire weight of 60,000 pounds would then be carried on this pair and none on the front and middle wheels. In like manner if the center of gravity be moved forward until it is directly over the front wheels, the entire weight will be borne by those wheels and none on the middle or back wheels, so that within the limits of the wheel base (which is ten feet in this case) the back or front wheels may be made to bear the whole load according as the center of gravity is moved in relation to the wheels. Therefore, to get an equal distribution of weight on the driving wheels of an engine in which the springs are not connected to one another by means of equalizing levers, it is necessary that the center of gravity of the supported structure be accurately located to suit the arrangement of wheels, otherwise the weight on each pair of wheels will be determined by a chance position of the center of gravity..

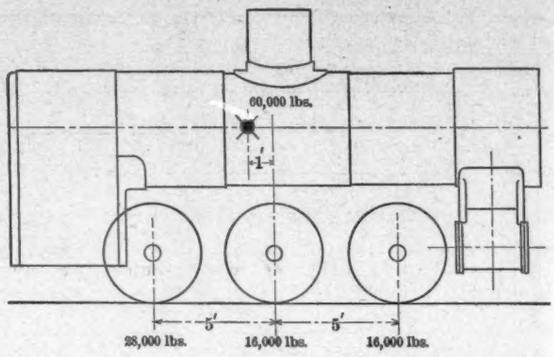


Fig. 3

This is best shown in its simplest form by a 4-wheeled switching engine, Fig. 4. The usual arrangement of the springs

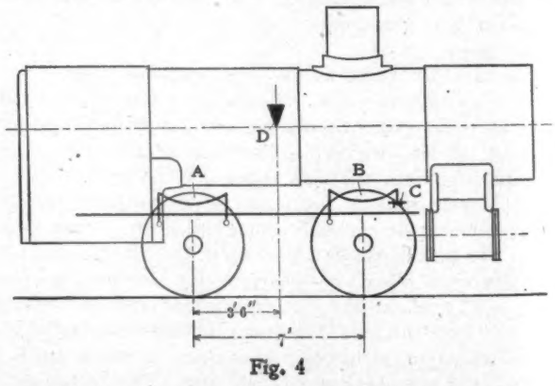


Fig. 4

is to fasten the ends of the rear spring A by means of its hangers to the frames; the back end of the front spring B is similarly fastened to the frame, while the front ends at C are connected transversely by means of a cross equalizer. This supports the engine at three points, namely: the rear axle or two back springs, and the front axle or a point midway between the center of the cross equalizer and the rear hanger of the front spring. It is evident that if the center of gravity of the boiler and its attachments is not directly upon the vertical line D between the two pairs of wheels, the weight will not be equally distributed.

In this type of engine, whether it carries its own fuel and water, or is provided with a separate tender, the center of gravity must be located midway between the wheels to obtain an equal load on both pairs of wheels. Longitudinal equalizing levers connecting the springs together sideways are not ordinarily used in this class of engine, owing to the increased pitching fore and aft which would result from their use and the

* For previous article see page 35.

exact balancing which would be required. If their use were permissible the arms could, of course, be made of unequal length to partially correct a faulty design.

The calculation of the center of gravity of a new engine, involves estimating or knowing the weight of each part and its distance from some assumed center. To work this out completely consumes considerable time, therefore frequently much is assumed from engines of similar build, the wheel weights of which are known. A case in point was a class of 4-wheeled switching engines with separate tenders, which were not only heavy in front but also were deficient in grate area. When more engines of the same class were required the balancing was improved by increasing the length of the firebox until the weight upon both pairs of wheels was equalized. The weight upon the front pair was decreased owing to the overhang of the addition to the firebox, with the center of the rear axle as a fulcrum, and the weight on the rear pair increased to an amount equal to the decrease on the front axle and the actual additional weight. The amount of additional firebox required was estimated and when they were built the result was not only perfectly balanced engines but the steaming qualities also were much improved. Another case was of a 6-wheel switcher, which was several thousand pounds too heavy on the front pair of wheels. One of these engines was accurately weighed so that the actual weight on each pair of wheels was known. Having this information, the amounts to add to the foot plate and to take from the front end could be readily obtained. As the back and main driving springs, Fig. 5, were connected by equalizing levers, any additional weight at C exerted a force at F equal to $\frac{W\ (A+B)}{B}$ and diminished the weight at the front axle G equal to $\frac{WA}{B}$. The extension front and front end of the frames were made as short as practicable and the effect of these changes calculated and plotted under each wheel until the decreased weights taken from the front wheels and added or partly added to the rear wheel produced the desired effect. The result was, when other engines of similar class were built that the distribution of weight was practically perfect.

In American practice it is customary to use equalizing levers, whenever practicable, to connect together the springs of the

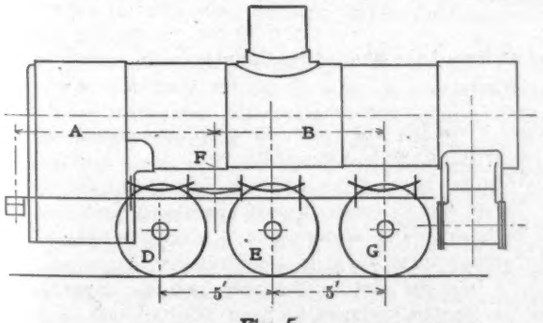


Fig. 5

different pairs of driving wheels. The principal function of an equalizing lever is to equalize the weight between two or more pairs of wheels; also to allow a maximum amount of vertical motion in any one wheel in its relation to the frame of the engine, without too great a deflection of its spring, or too great a variation of the load borne by that wheel. If the track is very uneven and an engine is run over it without equalizers, each spring must in turn deflect enough to compensate for its inequalities, and in doing so the load upon each spring is increased or decreased according to the amount the spring is deflected or released, and the load upon the springs belonging to the other pairs of wheels increased or decreased according to the undulation of the track. If, on the other hand, equalizing levers are introduced, the tension on the springs is uniformly maintained, by the levers rocking upon their centers and preserving equal wheel loads.

The arrangement of spring rigging for an American 8-wheel engine is shown in Fig. 6. In this type there is a 4-wheeled center bearing leading truck and two pairs of coupled driving wheels. The driving wheel springs are connected by means of side equalizing levers D attached to the frames by fulcrums at E. The engine is, therefore, supported at three points, namely, the truck center in front and the two equalizer lever fulcrums E, one on each side in the rear. If the fulcrums E are located centrally between the wheels (which is the universal method) the weight supported by each driving wheel will be the same. This applies only to the parts carried by the springs and not to the parts riding directly upon the axles or crank pins. For this reason the main wheels when weighed

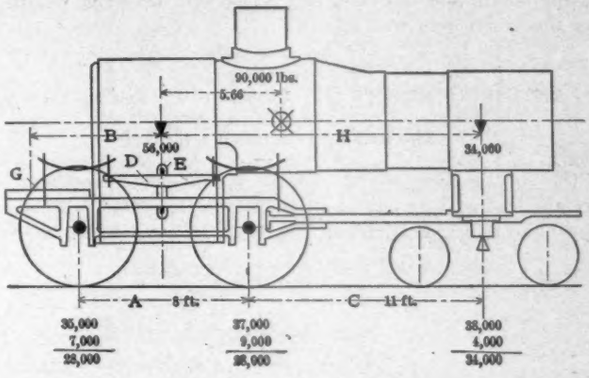


Fig. 6

will always be heavier than the back wheels, owing to the weight of the eccentrics and straps, part of the eccentric rods, the back ends of the main rods, and the additional counterbalance required. In this type of engine when the firebox is between the two driving axles as in Fig. 6, the average weight on the truck is about 36 per cent. and 64 per cent. on the driving wheels and when the firebox extends over the rear axle, 32 per cent. on the truck and 68 per cent. on the driving wheels. Owing to the excessive weight on the truck, when the firebox is between the axles, a very heavy footplate is often used to increase the weight on the driving wheels and decrease it on the truck wheels. The effect of a weight placed at G is to increase the weight on the drivers to an amount greater than the weight itself. This may be explained by reference to Fig. 6. Suppose 1,000 pounds is added to the foot plate at G, then the increase of weight on the drivers at E will be equal to $\frac{1{,}000 \times (B+H)}{H}$ and the decrease on the truck to $\frac{1{,}000 \times B}{H}$.

Example: Let B = 6 feet, H = 15 feet. Then

$$\frac{1{,}000 \times (6+15)}{15} = 1{,}400 \text{ pounds,}$$

the increase of weight on drivers, and $\frac{1{,}000 \times 6}{15} = 400$ pounds, the decrease of weight on the truck.

The center of gravity of the weight carried by the springs is found by making a diagram of the engine like Fig. 6. Under each driving wheel and under the center of the truck, write the weight in pounds resting on the rail. From these amounts subtract in each case the weights of the wheels, axles, journal boxes, springs and saddles. For the back wheels subtract also the weights of half the parallel rods and two crank pins, and for the main wheels half the parallel rods, two crank pins and 63 per cent. of the main rods, the eccentrics and straps, and half the eccentric rods. The remainder is 28,000 pounds on each pair of drivers and 34,000 pounds on the truck, making a total of 90,000 pounds exclusive of wheels, axles, etc. The center of gravity

of the weight on the drivers is evidently at the equalizer fulcrum, E. Write 56,000 pounds at this point and 34,000 pounds at the center of the truck. The common center of gravity of the two weights is found by multiplying the weight on the truck by the distance between the weights, and dividing by the sum of the two weights; the quotient is the distance from the rear weight, E, to the longitudinal center of gravity.

Example: Distance H = 15 feet. Then $\frac{34{,}000 \times 15}{90{,}000} = 5.66$.

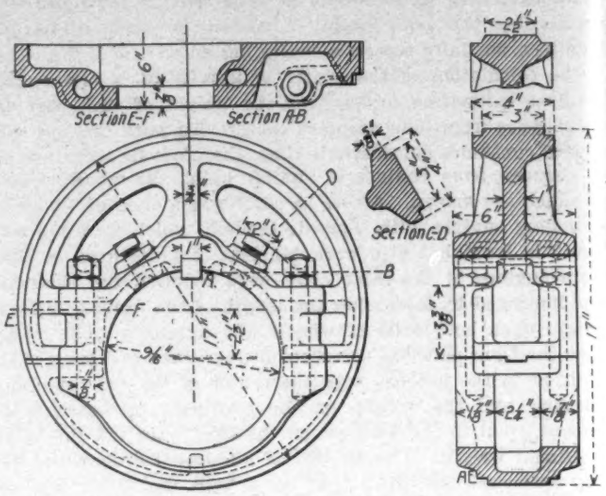
In this class of engines the weight on the truck is likely to be excessive; it is possible, however, to improve this somewhat by making the foot plate unusually heavy, and the bumper, smokebox extension, front and door as light as possible. Also by making the diameter of the boiler in front comparatively small, and the back end large, with as much wagon top as the conditions will admit.

(To be Continued.)

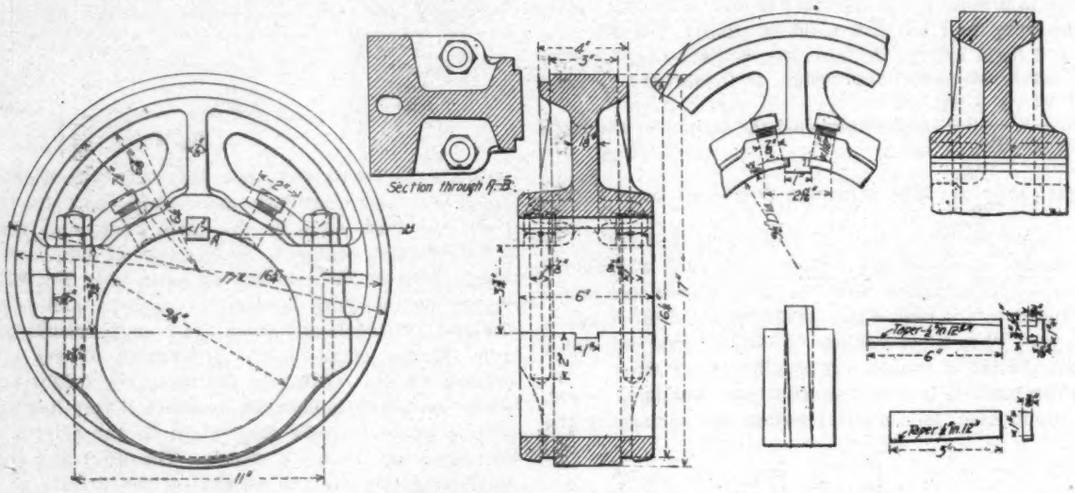
AN IMPROVEMENT IN LOCOMOTIVE ECCENTRICS.

The Brooks Locomotive Works.

One of the interesting details of the new passenger and freight locomotives built by the Brooks Locomotive Works for the Lake Shore & Michigan Southern Railway is an improvement in the construction of the eccentrics. Instead of putting in two bolts or studs to hold the halves of the eccentric together, the hub is widened out sufficiently to admit of using four of them. The design is an excellent one, which has been used by these builders on several recent orders. The engraving shows the design as applied to the Lake Shore engines, in which the hub was shortened somewhat and in which studs are used instead of bolts. The usual length of the hub is one-half inch greater than shown in the drawing. The object of this design is to prevent the eccentrics from working loose and wabbling on the axle, which is a common fault with the usual forms of split eccentrics upon powerful locomotives. It will be noted that the two halves of the eccentric are separated by a shim (No. 34 Birmingham Wire Gauge in thickness) when they are bored, in order that when bolted together upon the axle they will clamp it firmly and prevent any side motion or wabbling and at the same time be more secure against rotary displacement. It will be observed that the length of the axle fit is 6 inches. The shims which are used only in boring are removed before the eccentric is turned up, so that the outside when clamped on the axle is a true circle. This clamping device necessitates the use of four bolts or studs in order to insure perfectly true fitting of the two halves of the eccentric. The drawing shows the bearing portion of the eccentric and at once gives the impression of great strength in addition to the security of the fastening.



Design of Improved Eccentric, Showing a Large Saving in Weight by Coring.
Brooks Locomotive Works.

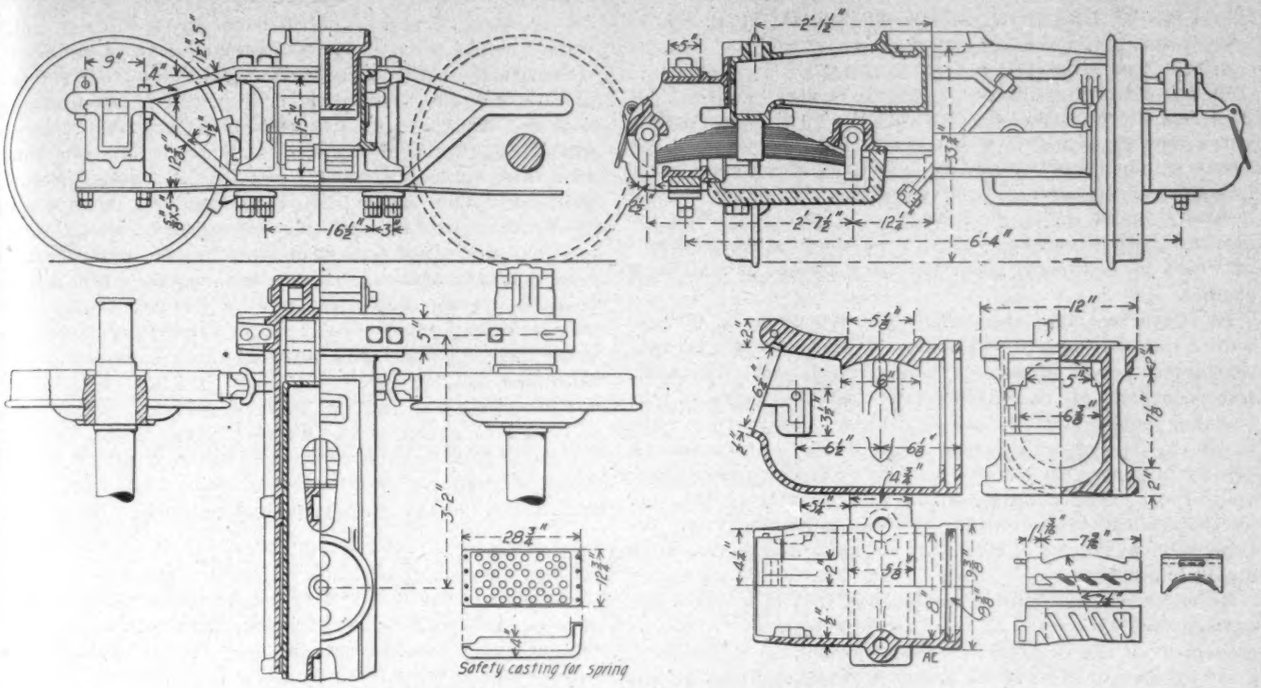


Improvement in Locomotive Eccentrics Used on New Lake Shore Locomotives.
Brooks Locomotive Works.

Two forms of set screw and key attachment are shown. In one the set screws bears directly against the axle and the key is 1 inch square in section and 6 inches in length. In the other arrangement there is a central key, a portion of which projects into the slot in the axle and the upper portion is fitted by tapered surfaces, inclined one-half inch in 12 inches, between two thin pieces, which are cut radially to fit the axle and against the tops of these the set screws bear. The tapered sides of these thin keys are cut to the exact size required after the valves are set. It is therefore possible to change the position of the ecentric upon the axle by changing the position of these keys, and by merely replacing the set screws. The movement may be ⅛ in. in either direction. Information is at hand to show that eccentrics of this type are giving excellent results in service.

The smaller engraving illustrates a later design by the Brooks Locomotive Works in which the long bearing of 6 in. on the axle is retained but with much thinner section of metal, which was done to save weight.

These are the greatest improvements in locomotive eccentrics that we have seen. This style of split eccentric is standard with the Brooks Locomotive Works for all heavy engines.



Cast-Steel Truck for Heavy Tenders, Louisville & Nashville Railroad.

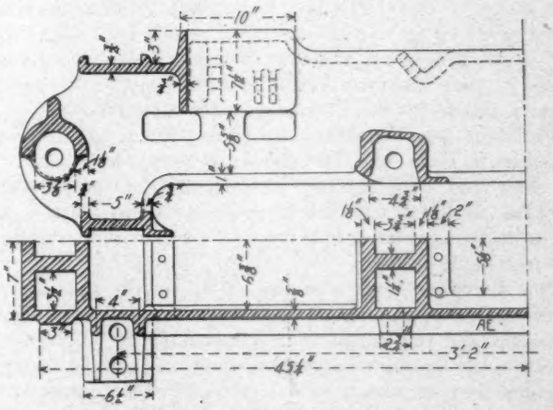
Designed by PULASKI LEEDS, *Superintendent of Machinery.*

CAST-STEEL TENDER TRUCK WITH DIAMOND SIDE FRAMES.

Louisville & Nashville Railroad.

The increasing weight of tenders for passenger locomotives making runs of 100 miles between stops has made it necessary for the Louisville & Nashville Railroad to provide a much stronger tender truck than has been heretofore used on that road, and the design shown by the accompanying illustrations was made and put into service by Mr. Pulaski Leeds, Superintendent of Machinery, about eight months ago. The truck embodies several interesting features, particularly with reference to the spring hanging and the arrangement of the journal brasses.

The fast passenger trains on this road are handled by 20 by 26-inch 10-wheel engines with large tenders, which, with their full capacity of water and coal, weigh 108,000 pounds. The side frames have arch bars 5 by 1½ inches in section, while the pedestal-tie bars are ⅝ by 5 inches. The bolsters are supported by two 31½-inch semi-elliptic springs at each end, making four springs for each truck. The springs are slung in forged hangers, which are provided for in the frame casting, as shown in the sectional views. Under the springs on each side malleable safety castings are bolted, the bottoms of which are perforated to save weight, and these castings are intended to catch the springs in case they break. We are informed by Mr. F. A. Beckert, Mechanical Engineer of the road, that this spring arrangement gives a very easy motion to the tenders. The center plates and side bearings are of the standard pattern used by this road and were provided in the design of the steel bolsters. The center plates have a large bearing surface. The journal boxes are provided with end stops and were designed specially for use under these tenders. The bearing of the journal brass in the top of the journal box is made crowning to a radius of 7¼ inches, the top of the brass being made to fit it. This is in accordance with the practice of Mr. Leeds in applying the load to the journal brass in such a way as to distribute the load uniformly over the entire length of the brass, instead of allowing it to come upon the ends, as is often the case with the ordinary brass and wedge. We are not told the weight of this truck, but judging from the sections of the castings it must be exceedingly strong, the metal being not less than ⅝ inch thick.



Half Section Through Transom.

Before placing these trucks in service the transom and bolster were marked with a prick punch, and the marks were referred to a very rigid three-point tram, which was done for the purpose of detecting any deflection or permanent set. No perceptible deflection was found in any of the parts when the tender was loaded, and none has been detected after eight months of hard service, in which the design has been found to be very satisfactory.

Water tubes through the fireboxes of a number of locomotive boilers on the Southwestern Railway, (England), were illustrated in this journal on page 79 in March, and page 223 in July of last year. "The Engineer" speaks of this experiment in the following glowing terms: "Mr. Drummond, of the Southwestern, has carried out a most successful experiment by putting in water tubes. These tubes, exposed to the full fury of the furnace gas, have been found to give no trouble whatever, while they greatly improve the steam making powers of the boiler."

We desire to call the attention of every reader of this paper to pages XVI. and XVII. of this number. If you do not have a paper, send 20 cents to the publication office and one will be sent to you.

F. W. DEAN ON LOCOMOTIVE PRACTICE.

In a suggestive criticism of locomotive practice before the New England Railroad Club recently, Mr. F. W. Dean brought out a number of points which are of special interest. Mr. Dean's standpoint is that of a Mechanical Engineer experienced in both stationary and locomotive practice. He appreciates the necessity for improving the locomotive in its use of steam and sees the possibility of applying to it in some degree the means of which have brought about the advancement of stationary engines.

Mr. Dean says that the desire of everybody to be through with a railroad journey will always make demands upon railroad companies in advance of their performances. The manifest conditions of passenger service are the desire of the traveling public to move quickly between distant points and to be surrounded with luxury while doing so. Increasing density of population shows a tendency to require more numerous short distance trains, which will probably be the field for the application of electricity to steam railroad service. Mr. Dean believes the use of electricity for main line service to be highly improbable.

He makes a good point when he says that if as much encouragement were given by the railroad companies to the improvement of the economy of steam locomotives as has been given by some of them to the improvement of electrical plants, or in changing smoke stacks and many other trivial things, the locomotive would probably leave the electric traction well behind in economy.

A desire to travel fast and to pull heavy trains leads to the building of larger engines and in a review of foreign practice Mr. Dean brings out the fact, without however commenting upon it, that the form taken in this direction abroad is to greatly extend the use of four cylinder compounds.

Professor Goss remarked upon his return to this country recently that the four cylinder compound was the only type of compound now making progress in Continental Europe. Perhaps Mr. Dean's failure to comment upon this fact is due to his opinion, which is in favor in the two cylinder rather than the four cylinder type.

The discovery that a stroke of 24 inches has no special virtue for the cylinders of locomotives, the use of higher steam pressures and the conspicuous increase of size of locomotives received the author's attention, and in boiler design the abandonment of crown bars is considered an important advance. Many of our readers will agree with him in objecting to the retention of former small grates in spite of the large increase in heating surfaces of recent years. The author of the paper says "There is very little to be gained by increasing heating surfaces unless the grate service is increased also. What is wanted most of all in large locomotives is more grate surface, for this is the heat making part of the boiler. More heat is wanted, and nothing but grate area can give it without difficulty and with economy."

In looking into the future the author warns against an "enlargement of defects" along with the increase of capacity. It is clear that he considers valves and valve motion as constituting a field for improvement with particular reference to the wire drawing of admission and exhaust, both of which operate to reduce speed and power and tend toward the use of cylinders that are too large to be economical. The loss of economy in the large cylinders is due to increased cylinder condensation and the extra work required to overcome back pressure. Mr. Dean does not deprecate efforts to reduce back pressure, but he strongly advocates more attention to the augmentation of the propelling pressure. The increase of propelling pressure has been ignored while the reduction of back pressure has received a great deal of attention with small results.

A fact worthy of careful thought is presented in a reference to the application of four Corliss valves to some locomotives on the Paris & Orleans Railway. It was shown that to these valves alone a saving of from 9.2 to 16.25 per cent. of water was due when compared with a slide valve engine of the same size and carrying the same steam pressure. Another engine in one year saved 15.2 per cent. of coal when compared with the average of 18 slide valve engines. The ordinary engine did 14,343 foot lbs. of work with one lb. of steam and the four valve engine gave 15,727 foot lbs., the steam pressure in both cases being 142 lbs. Mr. Dean makes no comments as to the probable reason for this, but if he did he would probably say that the advantages of the four valve engine lie in the reduction of clearance and in the fact that the steam ports and passages are not used alternately for live and exhaust steam. The time may come when the advantages thus obtained will more than offset the difficulties due to the mechanical complications.

RELATION OF CAPACITIES, GENERATORS AND MOTORS

In Electrically Driven Shops.

The proportion of generator and motor capacities in the electrical power plant of the Baldwin Locomotive Works, as stated on page 49 of our February issue, has attracted considerable attention, and it requires, perhaps, a little more explanation.

The original installation consisted of 700 horse-power of generator capacity to operate a total motor capacity of 2,000 horse-power. This was sufficient at the time because the average load at the switch-board was only 570 horse-power. The capacity has increased to 1,550 horse-power in the generators to operate 3,500 horse-power in the motors. Of this generator capacity one 250 horse-power unit is in reserve, leaving 1,300 horse-power in use. About 400 horse-power of the motor equipment is idle and in repairs, which makes the proportion 1,300 in the generator to 3,100 in the motors.

This motor capacity is the sum of the rated full load capacities of all of the motors, and many of them are of larger size than the average work calls for. This surplus is provided in order to take care of very severe service conditions at times. For example, nine-tenths of the time the machines may be working at finishing cuts while one-tenth of the time they will be doing extremely heavy work, calling for the full capacity of the motors. Mr. George Gibbs says that about one-third of the rated motor capacity will usually be ample for the generative capacity in large plants. In smaller plants, this rule would not always apply, especially when absolutely reliable service is required. In such cases a spare unit in the power-house is needed.

It is interesting to note in this connection the statement made by Mr. Burcham Harding, concerning the Westinghouse motors at the Duquesne works of the Carnegie Steel Company where the intermittent operation of the motors is carried on from the central station by means of one-sixth of the horse-power previously required when separate engines were used.

A draft rigging, which will sustain a load of 163,000 lbs. with a deflection of but 0.204 inch and will hold a load of 132,500 lbs. for 13 days without breaking is a good one. We are informed of a remarkable test of the Dayton Draft Rigging at the test room of the Robert W. Hunt Co. in Chicago, in which an initial load of 40,000 lbs. was increased by steps until it reached 163,000 lbs. with the above mentioned deflection, whereupon a key in the testing machine broke. It was impossible to take the draft rigging out of the machine for 13 days, during which the load fell from 163,000 to 132,500 lbs. Nothing could prove more conclusively that the design of this draft rigging is sound, that the material is good and that it is disposed favorably for transmitting and resisting enormous stresses. The rigidity of the structure and the simplicity of construction are reflected in the very small deflection.

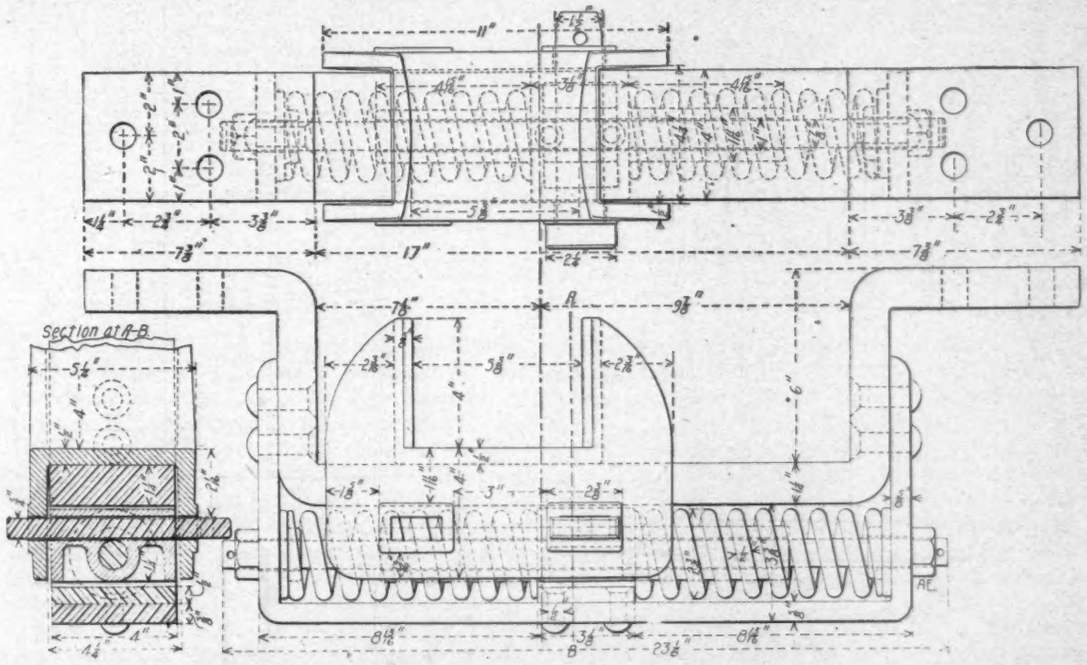
YERK'S SLIDING COUPLER YOKE.

The draw-bar sliding yoke shown in this engraving was designed and patented by Mr. G. Yerk, who is in charge of the platform department of the Pullman Palace Car Company at Pullman. It is being applied to the sleeping cars of that company, and several of the western roads are considering its adoption. The drawing was brought to our attention in the office of the Mechanical Engineer of the Burlington, Mr. F. H. Clark, and it is understood that a modification of the plan is likely to be adopted for all the passenger cars of that road.

The ordinary carry irons provide only about ½ inch play on each side for the relief of the coupler in taking curves. This is not enough, and Mr. Yerk has allowed a total motion of about 5 inches. The coupler shank is held in a malleable-iron yoke resting upon a carry iron 1¼ by 4 inches in section. The yoke has flanges at the front and rear, and by means of a key through these flanges the yoke is secured to a block which is held centrally between two springs of ½-inch steel. The springs are mounted in a stirrup below the main carry iron and they allow the movement of 2½ inches to each side of the normal position of the coupler. The side motion is limited by the lengths of the pieces of pipe through which the rod passes. Two positions of the yoke with reference to the central-spring block are provided, one for the shank of a Miller hook and the other for that of an M. C. B. coupler. The key may be withdrawn, the yoke moved over, and the key placed in the other slot, when it is desired to change the coupler.

The idea of this device is not new. It has been used on cars and on tenders, but its advantages are probably not fully appreciated. When the extent of the stresses due to lack of lateral play in couplers is understood, such devices will come into general use because of the relief from racking stresses which they give. The worst condition arises in connection with a car with a long overhang when coupled to a tender. On a sharp curve the car may derail the tender. Such accidents have occurred, and on the Chicago & Northwestern, several years ago, a test was made showing that the stresses imposed upon the framing are enormous. A number of lead blocks were made, and carry irons for a tender were put in with such a width of opening as to take in one of these lead blocks on each side of the coupler shank and give the coupler the usual amount of side motion. The tender was then coupled to a dining car with an overhand of 11 feet, and was pulled around curves of 20 degrees. The blocks of lead were compressed by the side thrust of the coupler, and in order to measure the amount of the pressure other blocks of the same original size as the first were compressed in a testing machine to the exact thickness of the ones which had been squeezed by the couplers. The pressure required to do this was 57,600 pounds, which is approximately a reproduction of the conditions of service. This is clearly an important subject.

We are indebted to Mr. H. M. Pflager, Mechanical Superintendent of the Pullman Company, for the drawing.



Yerk's Sliding Yoke for Passenger Car Couplers.

NEW GERMAN STEAMSHIP "DEUTSCHLAND."

The "Deutschland," launched January 10, for the Hamburg-American Line, at the Vulcan Yards, Stettin, is expected to be a record breaker. She will cost $3,332,000 and is to enter service between New York and Hamburg during the coming summer. She is being built under the rules of the German Navy, with protected rudder and steering gear, and will be used in naval service if required in time of war. Steam will be supplied from 12 double and 4 single boilers, with 112 fires, which drive two six-cylinder quadruple-expansion twin-screw engines of 33,000 horse power. The two propeller shafts are each 131.23 feet long and 24.8 inches in diameter; each of the bronze propellers being 22.96 feet in diameter. The ship has a double bottom extending its entire length, which is divided into 24 compartments; 15 exceptionally strong bulkheads extending from keel to main deck, and one longitudinal bulkhead in the engine room, divide the steamer into 17 watertight compartments. It is claimed that if two adjoining compartments were to fill with water the ship would not sink. The "Deutschland" is expected to have accommodations for 1,057 passengers and a crew of 525. There are 263 first-class cabins, 99 second-class cabins, and accommodations for 290 steerage passengers. The first-cabin dining saloon is located amidship on main deck, and has a seating capacity of 362. The following table giving the dimensions of the largest steamers is interesting for comparisons of the dimensions of the new ship with others:

Name of Ship.	Date.	Length over all. Feet.	Beam. Feet.	Depth. Feet.	Draft. Feet.	Displacement. Tons.	Speed. Knots.
Great Eastern	1858	692	*83	57½	25½	27,000	14.5
Paris	1858	560	63	42	26½	15,000	20.5
Campania	1893	625	65	41½	28	19,000	21.8
Kaiser Wilhelm der Grosse	1897	649	66	43	29	20,000	22.6
Oceanic	1899	704	68	49	32½	28,500	20
Deutschland	1900	684	66	44	†30	23,200	†23

*Over paddle box. †Estimated.

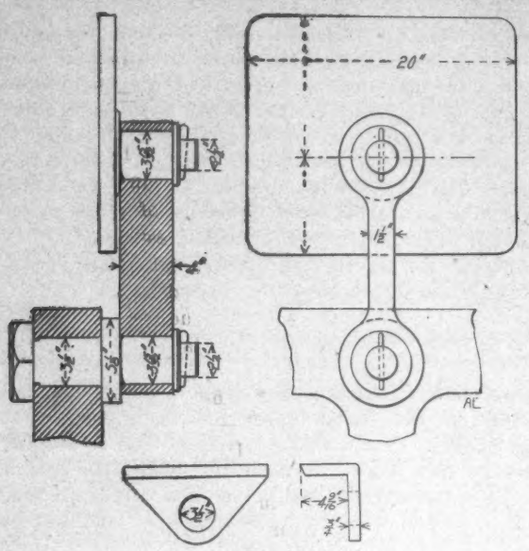


Fig. 1.

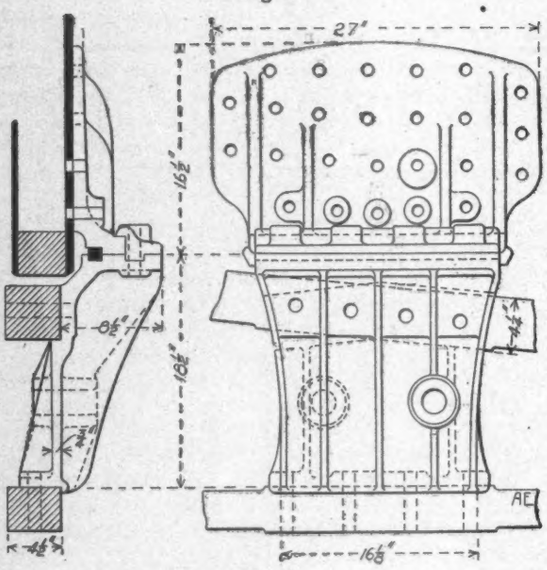


Fig. 6.

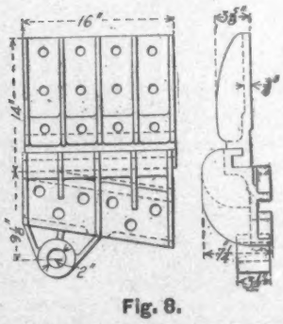


Fig. 8.

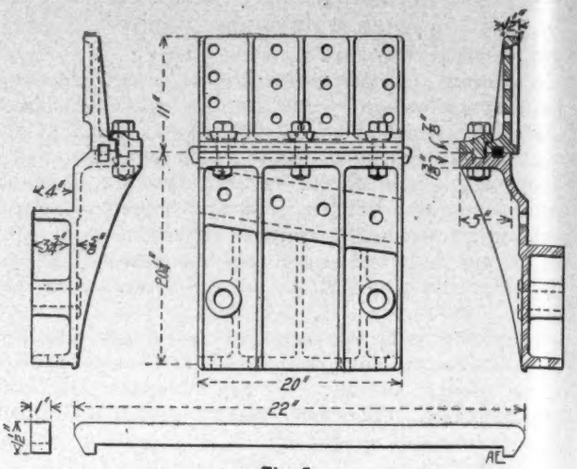


Fig. 5.

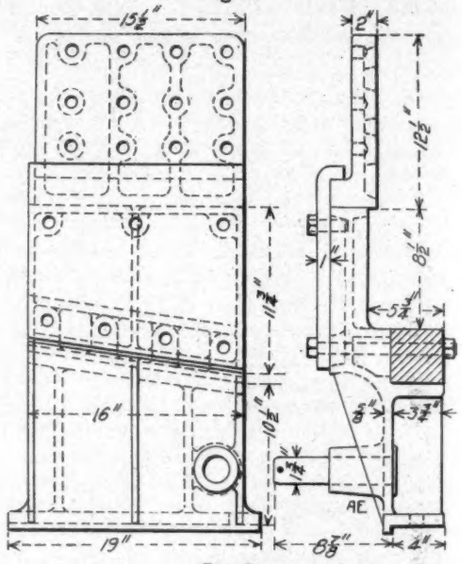


Fig. 7.

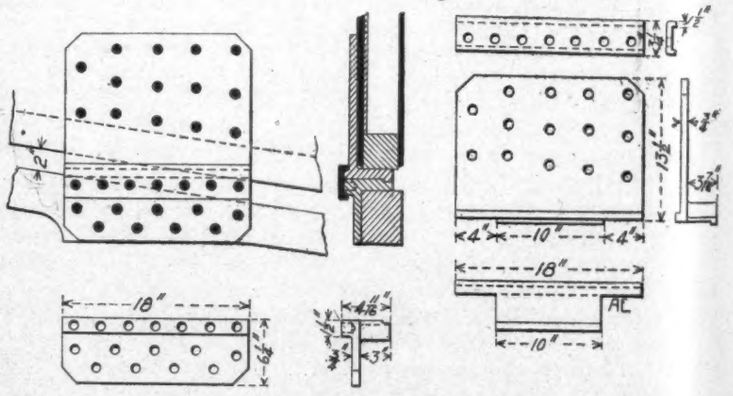


Fig. 9.

SUPPORTING REAR ENDS OF LOCOMOTIVE BOILERS.

When 52-inch boilers, carrying 140 pounds steam pressure and weighing 21,000 pounds, were common, it was not difficult to support them with satisfactory and easily maintained devices, but with the advent of boilers weighing 60,000 to 70,000 pounds, the problem is more troublesome.

Requirements.

The support at the front end being rigid that at the back end must provide for the expansion and the devices used must be light and inexpensive to maintain. They must distribute the load in such a way as to reduce to the minimum the vertical stresses in the frames, and they must provide for wear to be received upon parts which may be easily renewed and they should not only support the boiler, but hold it against surging stresses and provide for tensile stresses due to handling the engine in a wreck.

The best opinion seems to favor support from the mud ring and doing this with a view of keeping all attachments as close to the firebox as possible, making provisions for distributing the stresses over large areas. It is impossible to lay down rules for this detail because of the variety of conditions met in the design of locomotives of different types and for different purposes.

Support by Links.

The link method which has held a prominent place for a number of years, is not now generally favored because of the difficulties in maintenance. This is the lightest arrangement

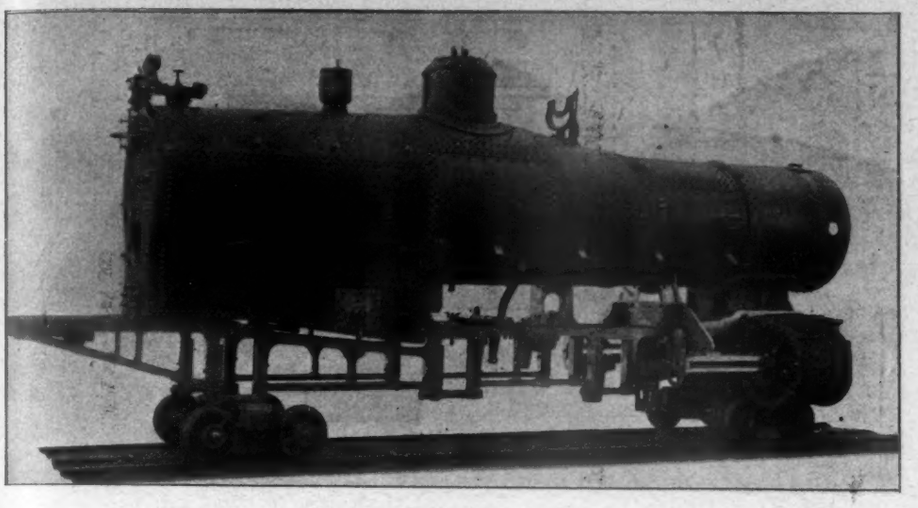


Fig. 1A.

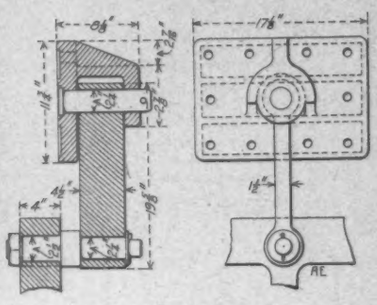


Fig. 2.

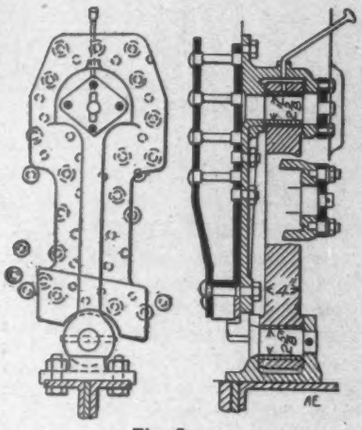


Fig. 3.

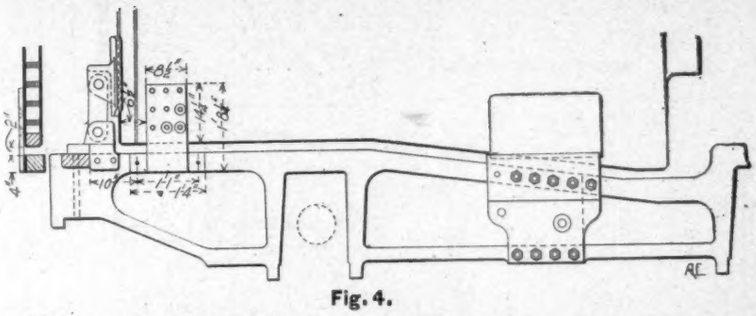


Fig. 4.

used and it has an advantage in being equally effective in tension and compression, and in a wreck or derailment this feature is valuable. The link has fallen into disrepute in some cases because of faulty design, but even when well designed and with very strong pins the bearing surfaces to receive the wear are not as large as may be desired. The pins must be long if the links are wide, and this sets up severe bending stresses in the sheets on account of the overhang or leverage.

Several designs are shown. The Schenectady Locomotive Works' link plan is shown in Fig. 1, and Fig. 1 A, the Richmond Locomotive Works in Fig. 2, and a design elaborate in detail, for the Austrian State Railways, in Fig. 3. The method of supporting the boiler direct to the equalizer by means of a strut between the bars of the frames is shown in the Schenectady design. The Austrian links have hardened pins and bushings and are provided with oil cups. This design may be criticised with many others because it is necessary to jack up the boiler in order to take the supporting devices down. The pads for the support of the upper pins are very large and even take in the mud ring. The oiling device for the Austrian links is a good idea which ought to be used on other arrangements such as pads.

The link arrangement used on the moguls of the C., B. & Q. is shown in Fig. 4. This has worked very well for a number of years. The links in this case are 2 by 4-inch rectangular bars with steel bushings, and the brackets are secured to the back of the firebox and to the ends of the frames. The side thrust is taken by plates secured to the firebox.

There are many advocates of the link method, and the fact remains that in spite of theoretical disadvantages it has done very well in some cases. There is a tendency to distort the sheets to which the pads are applied, which appears to be a serious objection. This is improved by the use of large pads. Many roads have abandoned the link in favor of other methods, while others have a large number of heavy engines supported in this way.

Pads Resting on Brackets.

The use of cast-steel brackets is quite generally favored. These are made in a variety of forms. The principles are about the same in all and the details vary according to circumstances. Those illustrated embody a support between the bars of the frame with supporting surfaces for the boiler, in which lateral and lifting stresses are provided for. In Fig. 5 the plan used in Schenectady engines for the New York, New Haven & Hartford is shown. Mr. Henney kindly furnished the drawing and stated that this arrangement has been satisfactory, giving no trouble whatever. The bearing between the upper and lower pads consists of a tongue and groove with a steel key to take the side thrust.

The large pads and brackets used in the new Brooks 10-wheel passenger engines for the Lake Shore (November issue, 1899, page 344) are shown in Fig. 6. These give good support and seems to work well in every way. They are, however, very heavy. The 10-wheel passenger engines built by the Richmond Works for the Southern Railway (our issue of March, 1898, page 83) have pads and brackets of the form shown in Fig. 7, by courtesy of Mr. W. H. Thomas. This plan gives a generous bearing for wear and large 1-inch plates lipped over the boiler pads take the lateral and lifting stresses. This is a strong design, but is not light in weight. Fig. 8 illustrates another form in cast steel which has been used by the Richmond Locomotive Works. It does not have the advantage of easily separating the boiler from the frames. The pads must be taken off in this case. This drawing represents a large class of boiler bearers made by several builders, but they are not the most convenient kind.

Mud Ring Support.

Two ways of supporting boilers by the mud rings are shown in Figs. 9 and 10. Fig. 9 is a design by the Richmond Locomotive Works as used with sloping frames. This plan has the advantage of removing the stresses due to the weight of the boiler from the pad studs to the mud ring, where they are received nearly centrally upon the frames without causing twisting moments. The design becomes simpler for level frames. This plan is simple, neat and strong. It places the stresses where they may be best provided for and the space

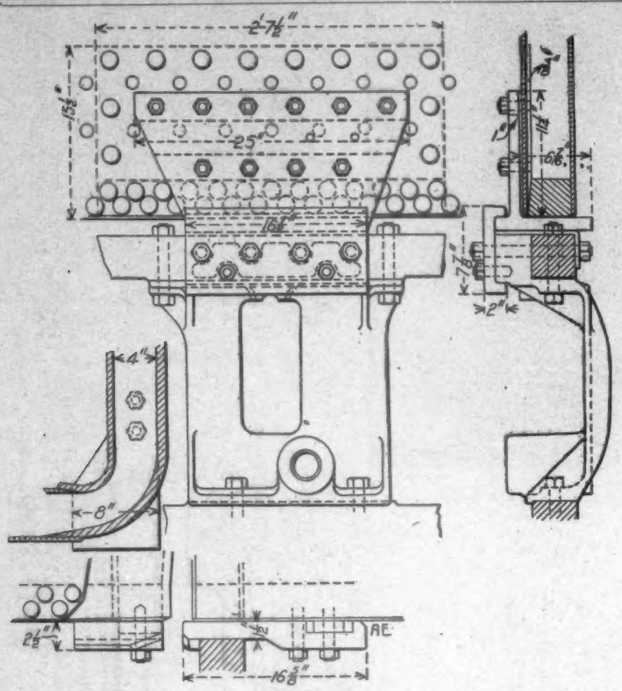


Fig. 10.

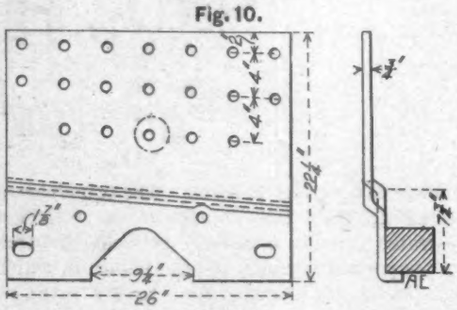


Fig. 12.

taken up is not required for other parts. This construction, being of wrought iron, is expensive, but we can not see any objection to it. The additional cost is believed to be amply compensated in the long life of the parts and relief of the firebox sheets from injury. The lip and shoulder in the bearing portions under the mud ring should not be overlooked.

A somewhat similar design is used on the heavy freight locomotives on the Pennsylvania, classes H5 and H6, as shown in Fig. 10, which is reproduced from the description of these engines in this journal (issue of June, 1899, page 181). In this case steel castings are fitted between the bars of the frames, terminating at the top in a long block, the top surface of which is flush with the top of the frame. Pads, secured to the boiler by studs, and provided with broad bearing flanges, receive the weight of the boiler and transmit it to the lower bearing surfaces, which are protected from wear by thin steel shims which are easily renewed. A ⅜-inch reinforcing plate is placed against the firebox sheet, inside the water leg, into which the studs are screwed.

This design has the important advantage of removing all tearing stresses from the studs in the pad. The firebox tends to push against the studs. This plan seems to meet all the requirements admirably and no fault has yet been found with it. It is the standard practice of the Pennsylvania.

The method of supporting by the mud ring shown in Figs. 11, 12 and 13 was used on the new Brooks consolidation engines for the Lake Shore & Michigan Southern illustrated in our February number. Fig. 11 shows one of the pairs of shoes placed under the mud ring. There are two pairs of these on each side of the engine. Those in front are very shallow, because they are fitted between the mud ring and the top bar of the frame where the space is not as great as shown in

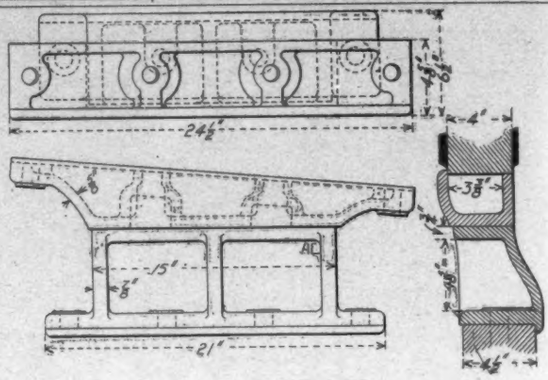


Fig. 11.

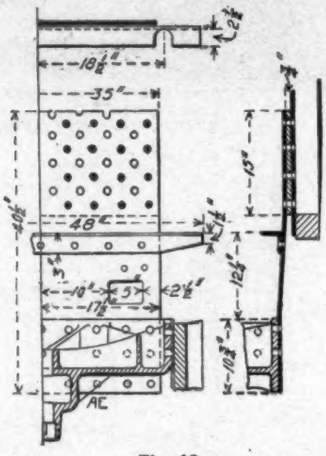


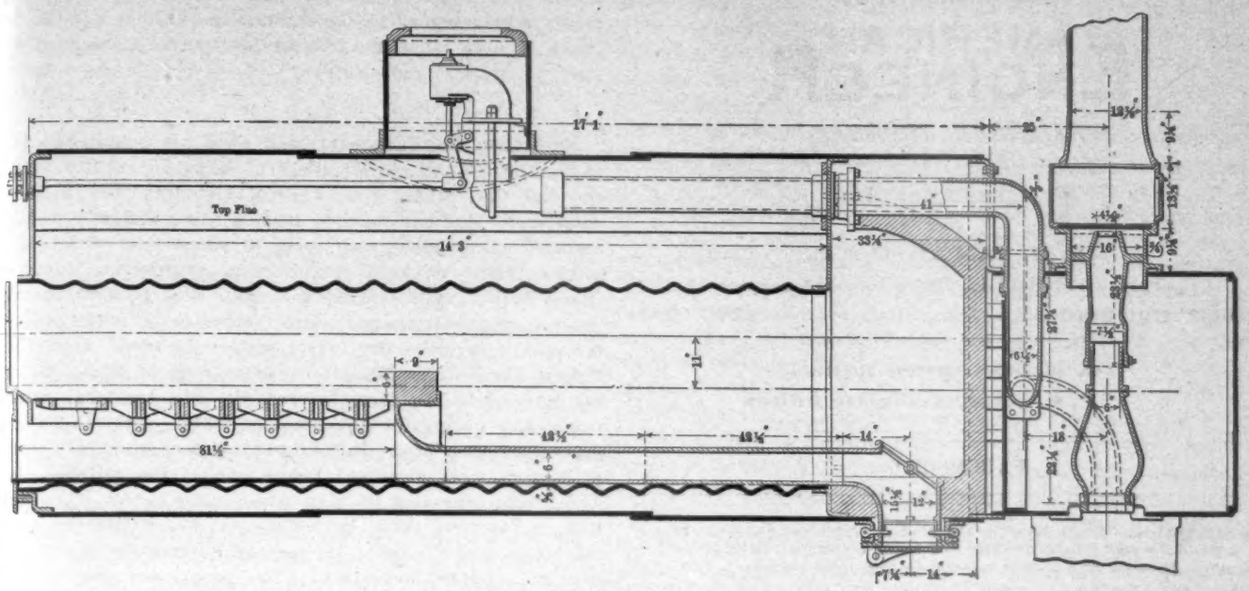
Fig. 13.

Fig. 11. These shoes are of cast steel and very light. They give no support against lateral or rolling stresses and they do not assist in lifting the frames by the boiler in wrecking operations. These features are provided chiefly by the large ½-inch plate of Fig. 13, which is secured to the back boiler head and to the front face of the cast steel foot plate. The boiler studs are ⅞ inch in diameter and it will be noticed that the plate is drilled opposite each staybolt. This plate may assist in carrying the weight, but it is not expected to do so. It distributes the transverse stresses over a large area on the back head and it seems to be an excellent plan. Plates have been used in this way for a long time on wide firebox engines. A ¾-in. plate, Fig. 12, is used to assist in furnishing attachment between the boiler and frames in a vertical direction. This plate covers the shallow mud ring shoes similar to Fig. 11. It also furnishes some lateral resistance. The chief object of this plan was to support the boiler safely with the minimum amount of added weight.

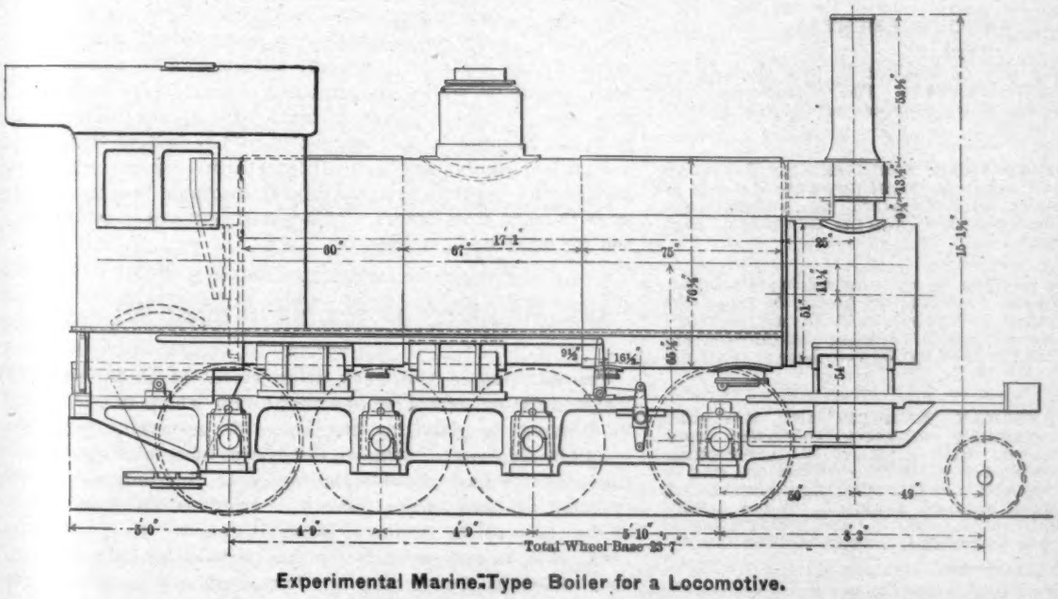
The necessity for lubricating boiler supports of whatever kind is not properly appreciated. Oil cups should be provided for links, brackets or mud ring supports. In link suspension it is not uncommon to find the surfaces rusted so tight as to defy release, except by removing the plates from the firebox. The resistance to motion in these parts when thus fastened together must necessarily throw undue stresses on other parts, and it is possible that some cases of broken cylinders and saddles may be explained in this way. The new Schenectady engines for the New York Central have oil cups to lubricate the boiler bearers. All of these devices ought to have facilities for oiling.

In using pads for vertical as well as lateral support, care should be taken to get them large enough to get in a sufficient number of studs.

The foregoing discussion may be summed up as follows: The best plan, wherever it can be used, is to support the boiler by the mud ring, or by the mud ring and by lateral plate braces. Next in order of excellence is the pad and bracket with area enough to give a large number of studs, while the link suspension seems to lack the best features of the bracket and mud ring plans.



Longitudinal Section.



Experimental Marine-Type Boiler for a Locomotive.
Atchison, Topeka & Santa Fe Ry.

A CORRUGATED FIREBOX, RETURN-TUBE LOCOMOTIVE BOILER.

Atchison, Topeka & Santa Fe Railway.

A novel experimental locomotive has just been completed at the Topeka shops of the Atchison, Topeka & Santa Fe Railway from drawings prepared under the direction of Mr. John Player, Superintendent of Motive Power of that road. The grates, which are of the rocking type, are placed in the rear end of a 40-inch corrugated, marine furnace flue, 14 feet 3 inches long, which opens at the front end into a "back connection," and the products of combustion pass backward through about 130 tubes to a cross connection at the cab end and thence pass forward through a plate duct along the boiler to a very small smokebox or chamber, into which the exhaust nozzle opens, to throw the blast up the stack. Air is admitted at the back end under the grates and also from a duct which opens under the bridge wall and brings air from under the boiler, just in the rear of the cylinder saddle. A butterfly valve may be opened between the front end of this duct and the "back connection" if air is needed at that point for perfect combustion. The ashes are raked out of the furnace at the back end, where they are received in a hopper which is slung under the deck of the cab. The bottom of the furnace is protected from the ashes, and the front of the combustion chamber from the heat of the flames. The arrangement of the steam and exhaust pipes and an idea of the exterior appearance of the engine are shown in the engravings. The idea of using a corrugated furnace in a locomotive in such a way as to secure a large amount of combustion space is new. This boiler is understood to be entirely experimental, but there seems to be no reason why it should not be successful. If it accomplishes nothing more than to do away with staybolts it will serve a most useful purpose. Attempts to improve the locomotive boiler are so rare that experiments of this kind ought to receive the heartiest encouragement. Locomotive men are so conservative about unusual designs that it requires a great deal of courage to bring out anything of this sort.

The attention of every reader of this paper is directed to pages XVI. and XVII. of this number. A copy of the paper will be sent to your address if you will send 20 cents to our publication office.

Recently, on the London & North Western, the Irish mail encountered a bale of cloth which threw several coaches over upon the freight track to be run into by a freight train. This seems like boy's play rather than real railroading.

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It is surprising and gratifying to see the results of our efforts to bring out the bright and experienced young men in the motive power departments and place them in communication with officers who are in need of their services. A statement of unsolicited response is printed on page XVII. of this issue.

A real reform is needed in the matter of salaries paid by American railroads to their motive power officers. In England the locomotive superintendent is paid a salary nearly as high as that of the general manager, and he is considered as one of the most important officials, although his duties cover no more, and generally not as much, ground as is the case in this country. No department of a railroad offers such opportunities for administrative wisdom to produce real economy as that in charge of locomotives and cars. No private employer would think of expecting a superintendent of motive power, for a salary of $3,000 to $5,000, to honestly and wisely administer expenditures amounting to several million dollars per annum. This is often done in railroad service. It is a difficulty which must correct itself in time. Those managements which recognize the importance of this question and make it clear that mechanical ability is appreciated are wise.

More than one successful man owes his beginning in advancement to the special study of some one subject and to the fact that others are aware of his proficiency in it. In some cases this has resulted from a paper before a technical association or good work done in connection with a committee report or as a part of an engineering investigation. Such a course is advantageous also because the very process of preparing one's information to be made available for others involves the crystallization of ideas, and a man always understands himself better because of trying to place his information in form for record. The technical associations offer means for advancement which ought to be more generally appreciated. Recently two papers which are worthy of remark were discussed before one of the railroad clubs. They were presented by men whose class is not often heard from in this way. One, on piece-work, was written by a shop machinist, and the other, on pooling locomotives, by an engineer of a freight locomotive. The papers are excellent, and that on pooling is the best so far produced on the subject. It is safe to say that these men possess qualifications which will lead to greater responsibilities. They have set an example which should be suggestive to many others who occupy much higher positions. Several able men who now occupy high positions while comparatively young have profited by this idea. Those we have in mind have a high professional principle in mind in this connection. They believe that when a man has secured professional information by study and experience he ought to give the benefit to others because he desires to learn from others. This is a strong and unselfish reason for what we advocate.

ARRANGEMENTS OF TRACKS IN ERECTING SHOPS.

The question of the track arrangement in shops, whether longitudinal or lateral, is one of the first which is considered in drawing up plans for new shops or in making improvements in old ones. There are differences of opinion, and some time ago we gave considerable space to this subject, rather favoring the longitudinal plan as a result of an examination of the shops of the Boston & Maine at Concord, N. H. Having been taken to task recently for this position by a Superintendent of Motive Power who has just completed plans for new shops, and being met with several good arguments, it seems advisable to present them. They come from one who has used both systems, and he strongly advocates the lateral plan from his experience.

The question of cranes versus transfer tables is the first to come up. He directs attention to the fact that a great deal of lifting of locomotives as a whole is required with the longitudinal tracks. This requires a heavy crane at each end of the engine, whereas a single heavy crane is required for the other plan. A second and lighter one, or two lighter ones, may be used for the cross-track shop if desired. It is also argued that a transfer table costs less than the second heavy crane.

One of the arguments against the long tracks is that the high lift required to carry locomotives over others standing on the same track necessitates a much higher, and consequently more expensive shop, because in this case the lift must be at least 20 feet, whereas in the other case the lift need be only sufficient to take the driving wheels out from under the engines, or from 6 to 8 feet. The same total length of track will accommodate the same number of engines in either case, but it is stated that the shop is much more cluttered up with the parts of engines in the long track plan, and an additional objection is that the pits of the long tracks must be covered with boards

when not in use, and even then the pits make it difficult to carry heavy parts about. These ideas may or may not be new to our readers, but the argument seems to be a good one. The cross-track system has the practical endorsement of the locomotive builders.

WHAT MOTIVE POWER OFFICERS ARE THINKING ABOUT.

Recent conversations with eight representative motive power officers, at their headquarters, indicate, by the voluntary introduction of the subjects, that the following are the most important lines for development in the immediate future:

Compounds.

The compound locomotive has gained ground remarkably during the past year. It has now become so well established upon one road where careful comparisons have been made for four years, that it is believed to be safe to say that nearly all future road engines for freight and passenger service there will be compounds. The records made by simple and compound locomotives, in the same service, on this road, show a saving by the compounds of 18 per cent. in fuel and between 5 and 6 per cent. in repairs in four years. On another road which heretofore has been satisfied to allow others to do the experimenting, a good-sized investment in compounds has been decided upon in confidence of securing advantage not only in fuel economy but also in repairs and in mileage. Carefully kept tonnage rating statistics have contributed to this result. With this turning toward the compound there is a noticeable tendency toward a proper consideration of satisfactory operation in the design of compounds. The provision of ample power when running in compound working is the most important factor to be kept in mind in ordering engines of this type.

Heavy Locomotives.

The heavy locomotive for both passenger and freight has a strong hold and the heavy engine is not at all a fad, but a recognized improvement in operation. Engineering departments are more liberal in the limitation of driving-wheel weights and managers are more appreciative of the necessity of favoring the locomotives by bringing the bridges up to the requirements. A general breaking down of the individual department idea is progressing. The engineering departments are less bitter in their denunciation of heavy engines because it is clear that they are needed.

Wider Fireboxes.

The coal situation throughout the west is such as to emphasize the importance of providing in the design of fireboxes for a much wider variation in the quality of fuel than has been considered necessary. Several of the important trunk lines have been seriously handicapped by the necessity of using coal that a short time ago was rejected. In one case 75 cars of coal actually refused and returned, four months ago, have since been cheerfully received and used for want of better fuel. This makes larger grates appear attractive not only because they offer greater leeway to meet the accidental state of the coal market, but also because they make it possible to use lower grades of coal. The extremely large grates required for anthracite coal are not needed with most western coals, but a moderate increase of area, obtained by increasing the width of the firebox, may be expected on several roads in the near future.

The Fireman.

The demands upon heavy passenger locomotives in use on a number of roads involve an amount of work for the firemen which is nearer the limit of their physical endurance than is generally realized. When all goes well a heavy passenger run is not so hard, but in zero weather, in snow storms with everything frozen that can freeze, with from 60 to 100 lbs. steam pressure for heating a train of from 10 to 14 heavy cars, the firing of the engine is a hardship. A regular run of 180 miles requires, say, 8 tons of coal in 4½ hours, with 8 cars. This is comparatively easy on the fireman in good weather, but when the train has an extra car, when the weather is bad and one-half hour is to be made up, ten tons of coal are handled by the fireman in 4 hours, or 2½ tons per hour. Three tons per hour is satisfactory work by a laborer in the coal chutes, where it is merely moved by the shovel, but the fireman must not only handle nearly as much as this, but he must place it skilfully on the grates, keep an eye on the steam gage, help the engineer with the water, and, what is worse, he must average several steps after each scoopful of coal. Men do this right along every day and little is thought of it. A question of two firemen on a locomotive may be up for settlement some day. That time will be deferred by aiding the fireman as much as possible. When there is an opportunity to do so, it is worth while to have a laborer shovel the coal forward at some water station stop to save steps for the fireman during the latter part of the run. The sloping tank is good, but it does not go far enough, and with coal containing much slack the shoveling is necessary, because it will not run of itself. The best way to relieve the fireman, which means also relieving the engine, the track and all, is to reduce the lost time to the lowest possible amount. Better attention to the signaling and the modernizing of water stations are labor savers which are not appreciated. When these are as they ought to be, there will be no slackening of speed on account of uncertainty about signals, and water station stops will be reduced to seventy-five seconds. Both of these items become very important in fast runs and especially when making up time.

This is a subject which is spoken of rather guardedly. It is, however, a most important factor, and will soon compel the consideration of improvements in the use of steam with a force that is not to be ignored. The tendency toward increasing the demands for steam was seen recently in a new way. It was on an engine hauling 14 cars in a passenger train. In order to heat the cars a special order was issued by the Division Superintendent to the engineer instructing him to carry a steam pressure of 80 pounds per square inch on the train heating system. The combination of severe requirements for passenger service, particularly in winter weather, is a matter fit to worry about, particularly because the end is not yet in sight.

Piston Valves.

Piston valves make friends everywhere and we shall soon hear of roads which will order no other valves. The opinion that this is one of the greatest improvements in modern locomotive designing is justified by the views of those who are best able to see its merits. The satisfaction with the principles of the piston valve appears to be universal where it is used, and the fact that it is being adopted in switch engines shows its present status. Central admission and hollow valves seem to call out the best and strongest endorsement. It is believed that this type of valve will soon be made to show greater improvements than have thus far been brought out. Experiments are now being made on an important fundamental and promising improvement in locomotive valve motion. In a short time it will be shown that locomotive cylinder clearances can be reduced to terms heretofore believed to be impossible of achievement. We shall seen see designs for applying piston valves to old engines to replace the flat valves upon the tops of ordinary cylinders.

Engine Failures.

Systematic watching of the failures of detail parts is practiced on a number of leading roads, and in consequence there is a remarkable reduction in the number of failures in service which formerly caused delays to trains. This is not a new idea but it is coming into more general use. There is no better way to study design than to observe the effects of improvements in the form of slight changes in the shape and size of parts. In crank pins, axles, piston rods and parts of valve gear and spring rigging, the effect is most marked. One of the best ways to keep these records is by aid of printed sheets

bearing, in copying ink, outline sketches of the various parts, upon which local officials may indicate the location of fractures; and on the same sheet space for explanatory remarks is provided. These, when collected for a definite period, furnish a great deal of positive information as a basis for changes in design, and subsequent records bring out the effects of those changes. This involves very little time and labor, and the returns amply justify the trouble. In fact this is the only way to secure this important information.

Car Construction.

In car construction the greatest amount of thought is being put upon methods for increasing capacity without unduly increasing weight. The high prices of steel account for a tendency toward the development of large capacities in wooden cars with deep trusses and metal bolsters. Next in importance is the improvement in draft gear. For freight cars strong and simple rigging is sought. This applies specially to those roads having recently put very large locomotives into service, some of which give a draw-bar pull of between 45,000 and 50,000 pounds, which is far beyond the capacities of the ordinary draft rigging. The result is that the front portion of trains hauled by these engines are running with the draft springs compressed solid. This is severe on the entire underframing of the car as well as upon the draft rigging itself. In passenger equipment more attention is being given to the lateral play of couplers. Several roads are considering the adoption of spring devices providing about 5 inches of total side play of the coupler shanks instead of 1 inch, which is the prevailing amount. This is a great improvement, particularly in cars having long overhang from the truck centers to the platforms.

Cost of Work.

The most elusive and, at the same time, most valuable information to the motive power officer, is the cost of doing work. It is very easy to omit important items in securing statistics of this kind, particularly in repair work, but in order to effect improvements intelligently such information is necessary, and it is apparent that clerical expenses are being increased with this fact in view. This tendency is reflected in many plans for new shops in which better methods of handling material and economies in the distribution of power are promised. It is not in the actual saving of power that the great advantage of this idea lies so much as in the saving of labor in running the shops and in the transportation of material. Some of the shops which are now being overhauled or supplanted by new ones now employ nine and even more independent steam plants, with the corresponding number of attendants. The centralization of the power plant into a single power station is the rule, and in several of these steam, electric, hydraulic and pneumatic machinery is so grouped as to permit of the minimum cost for attendance. In such a complex plant as a modern railroad repair shop it is necessary to provide all of these power distributing systems, and once having the facilities, each system may be called upon for the service to which it is best adapted.

Men.

Almost universal is the demand for men to take the responsibilities which the present unusual conditions of activity have created. There is a crying need for more systematic methods of training young men for advancement. The great number of changes made during the past year in the motive power departments of many large roads is impressive. It points forcibly to a serious weakness. Giving due weight to the occasional advantages of "new blood," these wholesale changes ought not to be necessary. Theoretically, every man should consider it a most important part of his work to educate and prepare his own successor. Subordinates should be selected with a view of the possibilities of advancement, and the most successful men of the future will be those who apply this broad and fundamental principle. It is easy to find roads in which the entire personnel of important departments are disheartened and discouraged by an utter disregard of this idea. An extreme case of this kind now exists in which seven men are wanted at once in the motive power department of one road. The necessity for this situation is doubted, and the attention of the presidents should be given to this question. It is one which is of vital importance to the stockholders.

The new President of one of our most important roads recently told the writer of his experiences on assuming charge of the property. After he had looked over the situation he met the heads of departments and division officers and told them what he expected them to accomplish in the first year. Some said it could not be done. The reply was: "My expectations are reasonable and you will be given every opportunity to carry them out. If you cannot secure the results others will be invited to try it, but I want you to do it." Very few changes have been necessary, and in three months several of the division superintendents had done that for which the President had allowed a year. This is far better than a "new blood" policy from the start. It has had an almost electrical effect on this road.

There is a strong tendency among railroad officers to follow details too closely. It is necessary to spend more time in perfecting such an organization as will place the responsibilities for detail upon subordinates.

What a difference it would make in great corporations if the heads of departments could get their work running so that they could sit down for 15 minutes every day and think!

CHICAGO & NORTHWESTERN SHOPS AT CHICAGO.

Extensive Improvements.

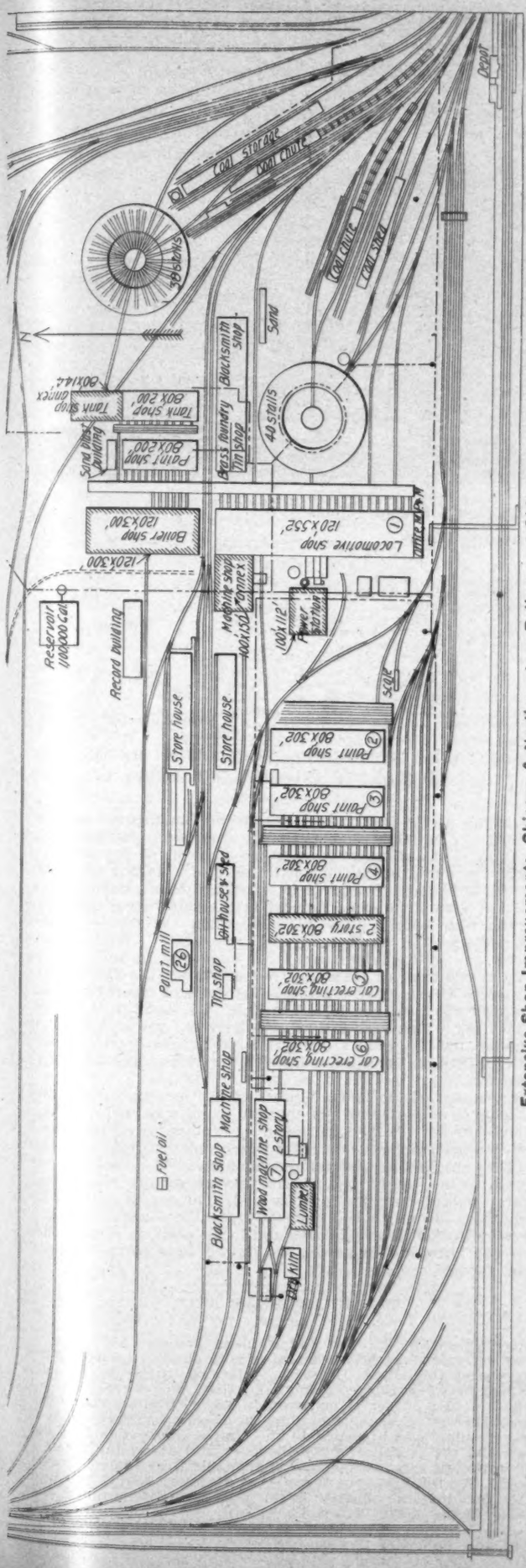
I.

General Scheme.

When the Chicago shops of this road were built in 1872 they represented the best practice of the time. They have not been kept up to date and increased demands necessitated the extensive additions and improvements which are now being carried out to meet the demands of that part of the road which is tributary to Chicago. The greatest need was in the boiler work and it was found that no part of the old boiler department could be utilized. This led to the consideration of these plans.

These shops are the only ones of any extent on the Galena and Wisconsin divisions, where the heaviest work of the road is done. The general repairs for these divisions and the heavy boiler work for the entire road and nearly all the new tank work is done here as well as nearly all of the making of new parts for locomotives and cars. As boiler making machinery is very expensive, it was considered advisable to concentrate all of this work here for 1,062 C. & N. W. engines, as well as that for general repairs of about 500 engines. When the firebox repairs of the Fremont, Elkhorn & Missouri Valley are included, boiler shop facilities for 1,185 locomotives were required, and this is provided in these plans. The complete scheme provided for other extensive additions, which, however, will not now be carried out. The car department will have two new buildings. The plan shown in the accompanying engraving gives the locations of the new buildings, of which there are three for the machinery department, besides an addition to the tank shop. A new power station, a new boiler shop, an annex to the machine shop, and an addition to the tank shop of 144 feet are now under way. The description in detail will be presented later.

The new boiler shop is placed north of the locomotive machine shop and has a floor 120 by 300 feet, with the main portion 67 feet wide. The riveting tower at the north end is 56 feet high and the wing is 67 feet wide by 20 feet high. The old boiler shop becomes the paint shop under the new plan. It is 80 feet wide and will be rearranged inside. At its upper end is an annex for the sand-blast apparatus used to clean old



Extensive Shop Improvements, Chicago & Northwestern Railway, at Chicago.

ROBERT QUAYLE, *Superintendent of Motive Power.*
G. R. HENDERSON, *Assistant Superintendent of Motive Power.*

paint from tender tanks. The tank shop is extended northward and these buildings are arranged to be served by an extension of the present transfer table at the east side of the machine and boiler shops. This transfer table pit will be about 900 feet long.

At the northwest end of the locomotive shop is the machine shop annex, in which all of the work of making parts of locomotives will be concentrated. This includes crank pins, piston rods, brass work and other details which are now scattered all over the large machine shop in such a way as to seriously interfere with the other work in the shop. This building is two stories high and it provides for a considerable extension of facilities beyond the present needs. It is 100 by 150 feet on the ground, the first story has 18 feet 6 inches head room and the second story 13 feet in the clear. There is an opening 42 by 132 feet through the second floor, with two foot bridges across the opening.

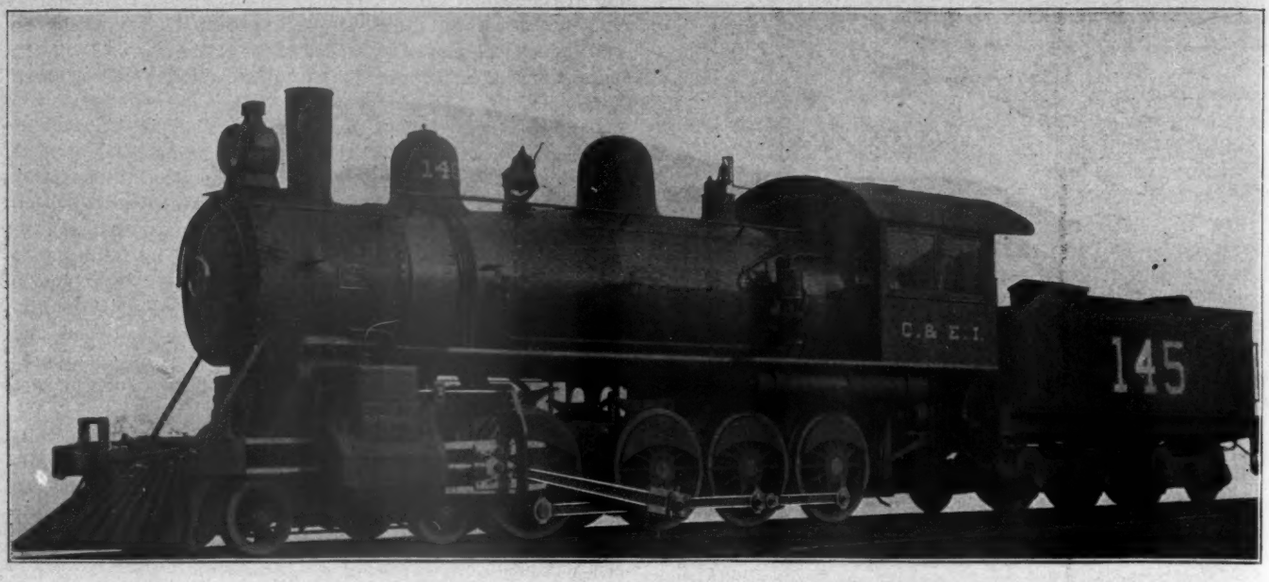
The tank shop, besides being lengthened, will have its walls raised to 24 feet 7 inches, which is the height of the walls of the new part. It will have a 30-ton traveling crane and ten tenders will be handled at once in this shop. It is admirably arranged, as will be seen in the detailed description.

An extensive improvement of the main locomotive shop, which combines the machine and erecting shops, was considered, with a view of providing adequate crane service, but the span of the roof, 120 feet, discouraged this for the present. It is now provided with a walking crane through the middle of the building and with small traveling cranes over the repair pits. At some future time this building will be raised or reconstructed in order to provide heavy electric traveling cranes capable of lifting locomotives.

This plant is also the most extensive on the road for the repair of cars. The new building south of the west end of the wood machine shop is for the storage of lumber. It is to be 40 by 140 feet, and the large one between paint shop No. 4 and car erecting shop No. 5 is to be 80 by 302 feet. This is to be divided into smaller shops, the quarter of the length at the north end being divided between pipe-fitting and buffing rooms. The upholstery shop is next, occupying about two-thirds of the length of the building, while the remainder is to be used for varnishing the sashes and blinds of cars. The entire upper story is for the storage of seats, cushions and other car fittings. All of the parlor cars of the road have separate sets of seats for winter and summer use, which necessitates considerable storage room.

In considering the distribution of power it was decided to allow the car department plant to remain as it is owing to the fact that its steam power is produced by the burning of refuse material. There were seven isolated steam plants, including that for the paint mill (building No. 26), which it seemed feasible to replace by a better system, as these all burned coal and involved separate attendance. The increase in the use of compressed air, in lighting and in power involved by the improvements led to the provision of an up-to-date power station in which all the steam, electric, pneumatic and hydraulic power systems will be concentrated. The boiler plant will have three 500-horse-power Babcock & Wilcox boilers with feed-water heaters and mechanical stokers, the draft being provided by a brick chimney, as this was considered a cheaper arrangement than the induced-draft system. The coal storage provides for 180 tons in hoppers in the boiler room. The engines are by the Ball Engine Company, the air compressor by Fraser & Chalmers, with a capacity of 1,500 cubic feet of free air per minute. The generators and motors are by the General Electric Company, installed by the construction department of the Chicago Edison Company.

Work has been started on all of the buildings, but it is now moving slowly on account of the difficulty in securing material. We are indebted to Mr. Robert Quayle, Superintendent of Motive Power of the road, for the plan and Mr. G. R. Henderson, Assistant Superintendent of Motive Power, for the details used in the preparation of these articles.



Twelve-Wheel, Two-Cylinder Compound, Chicago & Eastern Illinois R. R.

Built by the PITTSBURGH LOCOMOTIVE WORKS.

TWELVE-WHEEL TWO-CYLINDER COMPOUND LOCOMOTIVE.

Chicago & Eastern Illinois Railroad.

Built by the Pittsburg Locomotive Works.

This large two-cylinder compound has just been delivered to the Chicago & Eastern Illinois Railroad by the Pittsburg Locomotive Works, and it is interesting as another example of the appreciation of the principle of increased locomotive power for the hauling of heavy trains. The Chicago & Eastern Illinois has an exceedingly heavy coal business, and this engine was brought out for this service. It may be taken as an illustration of the wide acceptance of the heavy locomotive as a factor in reducing the cost of transportation.

The total weight is 182,200 pounds and the weight on driving wheels 144,000 pounds. This engine is somewhat lighter than the two-cylinder compounds of the same type built in 1897 for the Northern Pacific (see March, 1897, page 97), which is the design with which it compares most closely. With these weights in view, the heating surface of 2,273 square feet seems small. With but 3,800 pounds more total weight, the Northern Pacific engines have nearly 30 per cent. more total heating surface. The cylinders of the C. & E. I. engine are 21½ and 33 by 30 inches, and the driving wheels 54 inches in diameter. The valves are the American balance type. The following table gives the chief characteristics of the design:

Chicago & Eastern Illinois Railroad.—Weights and General Dimensions of Twelve-Wheel Compound Locomotive.

Fuel	Bituminous coal
Gauge of track	4 ft. 8½ in.
Total weight of engine in working order	182,200 lbs.
Total weight of engine on drivers	144,000 lbs.
Height from rail to top of stack	14 ft. 9¾ in.
Driving-wheel base of engine	15 ft. 6 in.
Total wheel base of engine	26 ft. 2 in.
Total wheel base of engine and tender	54 ft. 6 in.
Cylinders, high pressure, diameter and stroke	21½ by 30 in.
Cylinders, low pressure, diameter and stroke	33 by 30 in.
Slide valves	American balance
Piston rods	Cambria steel, 4 in. diameter
Type of boiler	Extended wagon top
Diameter of boiler at smallest ring	64 in.
Diameter of boiler at back head	72 in.
Crown sheet supported by radial stays, 1⅛ in. diameter.	
Staybolts, 1 in. diameter, spaced about 4 in. centers.	
Number of tubes	288
Diameter of tubes	2 in.
Length of tubes over tube sheets	13 ft. 6 in.
Length of firebox, inside	126 in.
Width of firebox, inside	41 in.
Working pressure	200 lbs.
Kind of grates	Cast-iron rocking
Grate area	36 sq. ft.
Heating surface in tubes	2,081 sq. ft.
Heating surface in firebox	192 sq. ft.
Total heating surface	2,273 sq. ft.
Diameter of driving wheels, outside of tire	54 in.
Diameter and length of journals	8½ by 10 in.
Diameter of truck wheels	28 in.
Diameter and length of truck journals	5 by 10 in.
Type of tank	Level top
Capacity of tank, water	4,500 U. S. gallons
Capacity of tank, fuel	320 cu. ft.
Weight of tender with water and fuel	93,000 lbs.
Type of brake	Westinghouse American

INTERSTATE COMMERCE COMMISSION RECORD OF ACCIDENTS IN COUPLING CARS.

Previous to its last annual report the Commission had expressed the opinion that until all cars were equipped, the advantages of automatic couplers as a means of protection to employees would not be demonstrated by the falling off in the number of killed and injured in coupling and uncoupling cars, and that view finds some support in the showing of casualties for the year ending June 30, 1898, when the number killed was 279 and the number injured was 4,988. While 1 employee was killed out of every 349 employed in 1893, and in 1897 the number was 1 killed to 647 employed, the figures were 1 killed to 518 employed in 1898. The ratio of injured to those employed was 1 to 13 in 1893, 1 to 22 in 1897, and 1 to 21 in 1898. In 1899, for which year full returns have not yet been made, it is found that 199 were killed and 5,339 injured upon 89 roads, while in 1898, on the same roads, 209 were killed and 5,484 were injured.

The causes of the large number of deaths and injuries still resulting to employees while engaged in railway operations are believed to be: (1) The increased percentage of inexperienced men employed since the decrease which resulted from the panic of 1893. (2) The greater number of tons carried per man employed, owing to the use of cars having greater weight and greater weight-carrying capacity. (3) The use of old and inferior cars, owing to the unusually great demands for transportation facilities on all roads and in all sections of the country. (4) The transition from the link-and-pin to the vertical-plane type of coupler.

THE BRAKEBEAM SUIT.

Editor American Engineer and Railroad Journal:

Our attention has just been called to a circular issued by the Interchangeable Brake Beam Co. referring to the patent suits pending between this company and that, and we beg to call attention to a material omission in their circular, viz.: They omitted referring to the fact that the case, prior to the date of their circular, was appealed to the United States Court of Appeals and the decision of which court will determine whether "the railroads can use the Interchangeable Brake Beam freely" or not. We think it only proper that attention should be called to the fact that the question is yet to be finally determined, and is still "in the court."

CHICAGO RAILWAY EQUIPMENT CO.

Chicago, February 15, 1900.

EDITORIAL CORRESPONDENCE.

Lake Shore & Michigan Southern.

The new 10-wheel passenger locomotives are continuing to do excellent work, and the freight engines, which we described last month, arrived in the nick of time. There were 25 of them and they came during a violent snow storm and went immediately to work in the emergency without the customary few days or weeks of nursing and petting to break them in. It evidently was a relief to the situation that was greatly appreciated because they gave no trouble whatever and they prevented a blockade of the road.

These engines are remarkably handsome. Their drivers are 62 inches in diameter which, with the exception of the engines built last year for the Lehigh Valley, are the largest ever used for the consolidation type. They are hauling trains of 2,800 and 3,000 tons on the main line, where the maximum grade is not over 16 feet per mile. They have hauled trains of 85 cars which means a total length of over 3,000 feet. The object of the large wheels was to insure speeds as high as made by the ten-wheelers previously in use, while the loads hauled are very much greater. They have already shown the value of this feature, for one was used in an emergency to haul "The Limited," which, we are told, was done in schedule time. Formerly the heaviest main-line freight engine was a 19½ by 30 in. ten-wheeler with 62 in. drivers and a total weight of 156,000 lbs. and 117,000 lbs. on the drivers. The new consolidation engines have a total weight of 168,000 lbs. with 149,000 lbs. on the drivers and 21 by 30 inch cylinders, and the same sized drivers as the lighter engines. In order to provide for the stresses due to 21 inch cylinders the main driving axle journals are 9½ by 12 in., which is one inch larger in diameter than the other journals. The total weight of these engines was limited to 172,000 lbs. The driving box brasses are relieved for about 1¼ in. on the main journals and 1½ in. on the others after the manner of truck brasses in order to reduce the area of contact between the brasses and the journals to that which really supports weight. The passenger and freight engines steam well and are very satisfactory. They exhibit the greatest saving in weight by the use of cast steel and the reduction of sections that is to be found, and they represent the maximum power that could be had with this weight.

Chicago & Northwestern.

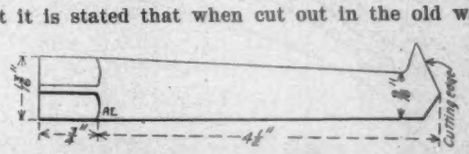
This road, in common with a number of western lines, is having difficulty just now in securing the grade of coal which they have been using, and for which their fireboxes are adapted. The reason for this is not as important as the effect upon the cost of the fuel and its action in the engine. The coal now received, and it is the best obtainable under the circumstances, though costing less than that formerly used, is really much more expensive because a great deal more is required. This points forcibly to the very great importance of the adaptation of the grates to the fuel, and not only to one particular kind of fuel. It is necessary to have more leeway in the choice of fuel, so that a variation, within reasonable limits, may be provided for to meet the requirements of the coals that are available. Mr. Quayle is rather more interested in the width of the firebox as a result of having to get along with poor coal for a while. He spoke with considerable favor of a moderate increase in grate area through an increase in width. It is not necessary to go to the large grate areas used in the East for culm burning, but we may expect to see a rational treatment of the wider firebox in the West in the near future.

Mr. Quayle and his assistant, Mr. Henderson, are very carefully watching the failures of locomotives on the road by means of reports returned by the division master mechanics. These reports are tabulated, and every six months the breakages are analyzed and discussed in a meeting of the officers of the department. This has resulted in a large reduction in engine failures, due to the information obtained in regard to the weakness which service develops.

The bulging of the side sheets of locomotive fireboxes has been investigated by Mr. G. M. Davidson, Chemist and Engineer of Tests of this road. He believed that the bulging of the sheets between the staybolts was one effect of the water used to wash out the boilers while hot, and proved his point. Four 24-inch square sheets of ⅜-inch boiler plate were cut, and one of them was secured to another, but thicker sheet, by staybolts as in the case of a firebox. The sheets were heated just below a cherry red and cooled by the application of a jet of cold water at the center. One of the sheets had two, one had six, and the third, twelve heatings and coolings. There was no application of exterior force, yet the sheets bulged under the stresses of contraction. The first bulged at the center to a height of about 2 inches, the second 5 inches, and the third 8 inches, showing the relative effects of two, six and twelve coolings. The sheet that was secured to another sheet, as in a firebox, was heated and cooled five times by the jet at the center, and afterward five times with jets in the four corners. The first treatment caused an outward bulge at the center, but this was drawn in by the other coolings until but a slight bulge remained. At the four corners, however, there were pronounced bulges, identical in appearance with those found in fireboxes which are worked hard in service. The staybolts were all loosened so that they would leak if put under pressure; but it should be clearly understood that the stresses in these experiments were entirely and solely those due to expansion and contraction. The conclusion drawn is that cold water injures firebox sheets and that the bulging so often found is probably due to this cause. It may be prevented, or at least improved, by furnishing enough engines so that the time for cooling off may be allowed before washing out. This, however, may be much more expensive than the frequent replacement of the side sheets.

Two new methods of removing fireboxes are being developed on this road. In both of these, pneumatic drills are employed to drill into the staybolt through the outside sheet. Then in one of the methods a tool made somewhat like this sketch is placed in the drill hole and, driven by pneumatic power, it cuts off the staybolt at the bottom of the drilled hole.

The other method is even simpler than this. The staybolts are drilled through the sheet as before, the hole being ¾ inch, or larger, according to the size of the staybolt. A punch like those used by blacksmiths is then inserted in the hole, and when struck a blow with a sledge, the bolt breaks off. We have no record of the time required for this method, but for the first it is stated that when cut out in the old way, with



Device for Cutting Staybolts.

a chisel and sledge, 90 man-hours were required for a firebox containing 896 staybolts. This has been reduced to 15 man-hours by the use of the new tool illustrated. With smaller fireboxes the time is much shorter. One man now does the work alone, and any portion of a side sheet may be removed without taking out the mud ring or the back head.

Mr. Henderson has worked out an usually complete individual record for locomotives, giving the characteristics of each class and the special equipment. It has 11 columns to record changes when repaired. He has also compiled a record of machine tools in the possession of the road, giving the original cost, size, age and present value of each, the name of the maker, and shop in which it is used. He has made a simple improvement in ordinary shop air hoists for the purpose of cushioning the upward motion, in order to prevent the piston from striking the upper head hard enough to cause the load

to jump off the hook. He merely drills a small hole in the top head to allow the air above the piston to escape slowly, and the cylinder thus acts as a dash pot to stop the motion gradually.

Columbus, Hocking Valley & Toledo.

This company has just completed a large coach paint shop, adjacent to their repair shops, which is a great improvement over the previous arrangement, in which the painting was done at a distance of several miles from the main locomotive repair works. The freight equipment is being overhauled, a large number of large-capacity cars have been built, and many light engines with 16-inch cylinders are being increased in power by the building of larger boilers and the use of larger cylinders. This is essentially a coal road, and the passenger business is relatively light. Mr. Stiffey, Superintendent of Motive Power, has recently fitted up the entire plant with air pipes, and pneumatic power will be used for all work to which it is adapted.

This road has been testing Lucol spraying paints with great satisfaction because of the rapid work which its use permits. This spraying paint "sets" more rapidly and it covers more area than other paints. Cars are not detained as long as before because they are finished very quickly. In most cases one coat of the Lucol is sufficient, and answers for two coats of some other paints, and thus the car is kept out of service for painting but 12 hours instead of 24. It is common practice to paint and letter a car in 12 hours at these shops. The tests on this road were made out in the weather when the temperature was 10 degrees below zero. Under such severe conditions there was no sign of crawling or crinkling of the paint on the iron work or on the galvanized-iron roofs, as would be seen with linseed-oil paints.

GRAPHICAL TREATMENT OF HELICAL SPRINGS.

By Edward Grafstrom.
Mechanical Engineer Illinois Central R. R.

In the "American Engineer and Railroad Journal" of December, 1898, page 396, and following, Mr. F. J. Cole had an interesting article on "Springs," in his series on "Locomotive Design," and many readers have probably found the diagram of working loads and deflections for semi-elliptical springs very convenient and useful in proportioning springs of this kind. The writer regretted at the time the paper was published that a similar diagram had not been furnished for helical springs, for which the mathematical formulas are perhaps still more unwieldy than for the elliptical ones. Since then there have appeared, in several European papers, diagrams for similar formulas, and as such diagrams can be adopted to graphically illustrate the expressions of which Mr. Cole made use, the writer submits an example herewith, believing it to be original, at least as far as the deflection is concerned, and hoping that it will be found a useful adjunct to Mr. Cole's excellent article.

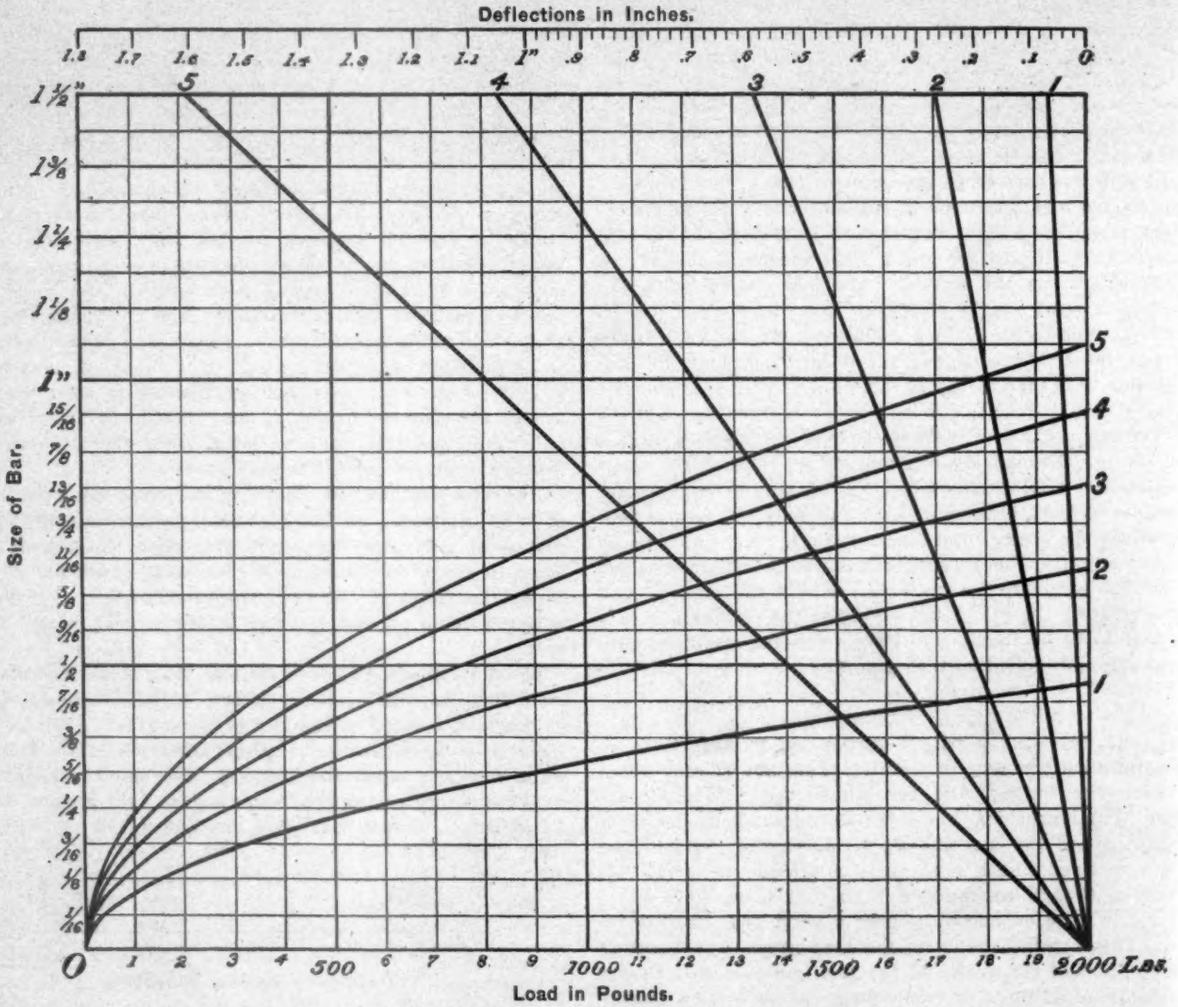


Diagram of Working Loads and Deflections of Helical Springs.

In order to understand the development of the diagram, the following explanation will be necessary. The symbols are the same as used by Mr. Cole, viz.:

P = working load.
d = diameter of steel bar.
R = radius to center of coil.
D = deflection of spring under working load.
G = modulus of shearing elasticity, 13,000,000.
L = length of bar before coiling.
S = working shearing fibre strain, 45,000 pounds.

M = number of coils.

Considering now the first formula used by Mr. Cole:

$$P = \frac{8\pi d^3}{16R}$$

it can be re-written thus:

$$P = \frac{\pi}{16} \cdot \frac{d}{R} \cdot S \cdot d^2.$$

By calling the expression

$$\frac{\pi}{16} \cdot \frac{d}{R} \cdot S = C,$$

we get $P = C \cdot d^2$, which will be recognized as the equation for the parabola, whose curve can now easily be drawn by inserting the numerical values of π and S, and assuming a certain ratio for R : d. In the accompanying diagram this ratio has been taken as 1, 2, 3, 4 or 5, and five parabolic curves drawn accordingly, with the point O as vertex, P marked off along the abscissa, and d measured on the ordinate.

For the deflection Mr. Cole uses the following formula:

$$D = \frac{2RSL}{dG},$$

and for L the equation $L = M2\pi R$.

By combination we then get:

$$D = \frac{2RS}{d} \cdot \frac{M.\pi R}{G},$$

which expresses the total deflection in the whole spring.

In order to reduce it to deflection per coil, M will now be dropped:

$$D = \frac{2RS}{d} \cdot \frac{2\pi R}{G}.$$

Dividing this by d, carrying out the multiplications, and rewriting the equation, we get:

$$\frac{D}{d} = \left(\frac{R}{d}\right)^2 \cdot \frac{4\pi S}{G}.$$

After inserting the numerical values of S, G and π, it appears thus:

$$\frac{D}{d} = \left(\frac{R}{d}\right)^2 0,0435.$$

It will now be seen that this is the equation for a straight line forming with the ordinate an angle, the tangent for which is equal to 0,0435 multiplied by the square of the ratio between R and d. Assuming this ratio as before to be 1, 2, 3, 4 or 5, five straight lines have been drawn on the diagram, for convenience's sake with negative abscissa from the lower right hand corner, and the scale for measuring the deflection has been drawn above the diagram in decimals of inches in order to be comparable with Mr. Cole's table for the deflections of helical springs. By multiplying these deflections by the number of coils the total deflections of springs can be obtained.

As an illustration of the use of the table, we will select a spring for a load of 1,500 pounds, and suppose that space makes the ratio R : d = 4 most suitable. By following the vertical line drawn through the 1,500-pound mark until it cuts the parabola marked 4, and then following a horizontal line through this point to the left margin, we come to the 13/16-inch mark, which is then the diameter of the bar. The same horizontal line cuts the angular line marked 4 at a distance from the right hand margin, which projected on the decimal scale at the top gives us 0.57 inch, which is thus the deflection per coil.

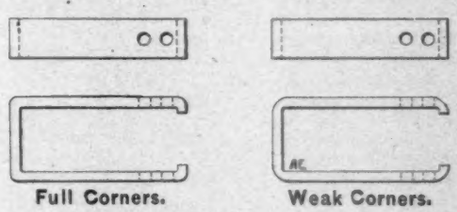
For comparing the results obtained from the diagram and the table, we will take a spring of ¾-inch steel and 5¼ inches outside diameter. The diameter at the center of the coil is then 5¼ − ¾ = 4½, and R is consequently 2¼ inches, which, divided by ¾, gives a ratio of 3. By following the horizontal line through the ¾-inch mark, we find that it crosses the parabola marked 3 between the vertical lines drawn from the 1,600 and 1,700-pound mark, nearer the latter. This gives then the capacity of the spring. We also find that the same horizontal line intersects the angular line marked 3 in the same point. The distance from this point to the right hand margin, projected on the scale above, gives a deflection of very nearly 0.3 of an inch. Comparing these figures with those in Mr. Cole's table, we find that the corresponding values are given as 1,657 pounds and 0.293 inch.

It should be said in conclusion, that the diagram is based on an average fibre strain of 45,000 pounds, whereas in Mr. Cole's table the fibre strain varies from 40,000 to 50,000 pounds, which makes a small difference in comparing the values obtained from the diagram and from the table.

WEAKNESS OF DRAWBAR YOKES.

An important improvement in the construction of drawbar yokes was made several years ago by the Cleveland City Forge & Iron Company. It is now an absolute necessity in view of the present situation with regard to draft gear. The attention of a representative of this journal was directed to the difference in the draw bar yokes as made by usual methods, and by the special method used by the firm referred to. This led to a personal examination of the manufacture at their works, which led to the conclusion that the process is not generally known. Those who know about it buy no other yokes though the price is higher.

At a recent meeting of the Central Railroad Club, Mr. West of the New York, Ontario & Western stated that upon replacing



Improvement in Drawbar Yokes.
Cleveland City Forge & Iron Co.

the original tail pins of the draft gear on that road with yokes, nearly as many breakages occurred as before, although the yokes were made of 1 by 4 inch iron. The back ends, which were presented to the followers, broke away from the two parallel side portions. This was thought to be due in some cases to the iron being "red short" and when bent the temperature was such as to start cracks at the corners. The shocks and stresses of service soon finished the fractures.

The fundamental trouble, however, is with the shape of the bends. If the M. C. B. lines are followed, it is necessary to make a short bend at the corners, and notwithstanding the recent increase in the radius from ¼ to ⅝ in., the short bend as ordinarily made reduces the thickness of the iron at the angle, some, recently examined, being reduced to ¾ in. and less. Mr. West referred to the fact that the Cleveland City Forge & Iron Company was manufacturing yokes in which the difficulty was overcome, and Mr. Waitt immediately stated that purchasing yokes from these makers probably accounted for the fact that the Lake Shore had been entirely free from the trouble.

The increased radius helps a little, but it remains impossible to avoid thinning the metal down unless it is specially provided for in the forging. The yokes referred to thus favorably are made in two operations. The first bends the yoke roughly to shape and the second presses it into final form over a mandrel. This is done in a specially powerful forging press, and the clearances are made in such a way as to upset the metal so as to fill out the corners and it is upset only at the corners. By this method the section of the iron at the corners is increased over the original section, and this will be readily seen to be a decided advantage, as it furnishes the largest section where it is most needed.

COMPOUND LOCOMOTIVES.

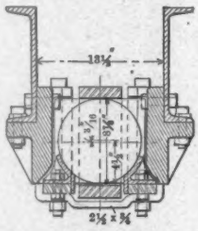
Disposition of Steam in the Two-Cylinder Type.

Mr. F. W. Dean, in discussing locomotive practice, before the New England Railroad Club, stated that he regarded the compound principle as "the greatest improvement that has been introduced into the motive power departments of railroads."

This is the greatest improvement in such engines that has been made since locomotives were first built, for two reasons; first, because it is the only improvement in principle that has been widely applied, and second, because it is the only fundamental means of economy of fuel and water that can be applied. That it is successful in realizing economy is no more a matter of doubt than that the sun shines.

A type of engine that can save nearly one-quarter of the coal now used by simple locomotives; that reduces water consumption by 15 to 20 per cent.; that steams better than simple engines in hard places; that reduces smoke, cinders, and the fire risk; that diminishes boiler and slide-valve repairs, and that does not necessarily increase repairs of any kind, must be adopted as soon as it is intelligently designed and prejudices are relegated to the background. . . .

The question as to the type of compound locomotive is likely to arise frequently, and it can be laid down as a safe belief that the two-cylinder compound is more economical than that having any greater number of cylinders, for the reason that it has the least surface for condensation per unit of piston displacement. In large sizes, however, except for freight service, it is difficult to obtain sufficient port area for the low-pressure cylinder unless a departure is made in the valves from the ordinary practice. In fast work I believe that such engines will not be as economical as we have a right to expect unless a departure is made. The loss of work between the cylinders will counteract the economy to a greater or less extent than is due to the compound principle.



Section at A-B

The effect of the compound principle is persistent, and its economical result cannot be prevented except by the introduction of phenomena that come from improper designing. The defect above all to be avoided is the loss between cylinders is so insidious, so to speak, and so little comprehended, that it should be dwelt upon sufficiently to make its causes and nature clear. It cannot be done away with, even in slow-running pumping engines, for even there some work must be absorbed in transferring the steam from one cylinder to the other. In addition to this cause, the various resistances produced by obstructions and abrupt changes in direction of the steam passages are to be noted. The steam in passing out of the first cylinder through the intercepting valve, where this is used, and through the open port of the low-pressure cylinder, is considerably retarded, and a loss of pressure is produced. Engines having piston valves suffer from this loss because the steam has to pass through gratings which form the ports. Engines that have the intercepting valve on the low-pressure side are much subject to this loss, because the steam is rapidly drawn from the receiver by the low-pressure piston through this restricted opening. If this valve is on the high-pressure side, the steam passes through it only as rapidly as it escapes from the small cylinder, and this is only some one-half to one-third as rapidly as it is drawn into the large cylinder. This shows the importance of placing the intercepting valve as near the high-pressure cylinder as possible.

Having considered this loss, we are in a position to appreciate the reason why certain compound locomotives are highly economical, when working slowly, or even moderately fast, with heavy trains. In these cases, in consequence of late cut-offs, yet with considerable expansion and somewhat slow movement of the steam, the losses described are small, and bear a small proportion to the total work done. The result is that the compound is enabled to bring out its valuable qualities undiminished.

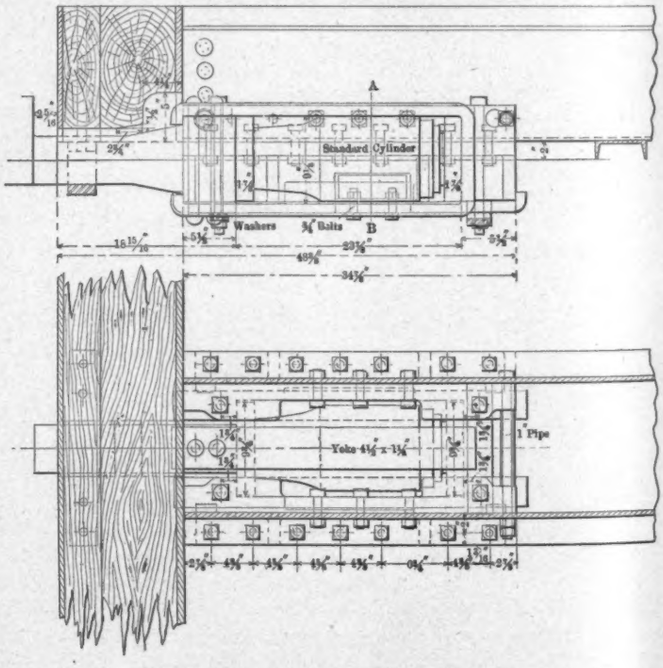
Most compound locomotives have a low-pressure port ridiculously small, so small, in fact, that, while simple engines require an extravagant velocity of steam through ports, even as high as 1,500 feet per second, some compounds have it two or three times as great. In such locomotives the loss between the cylinders is enormous, and the engine becomes useless for high speeds.

WESTINGHOUSE FRICTION DRAFT GEAR.

Applied to Tenders of the Union Railroad, Pittsburg.

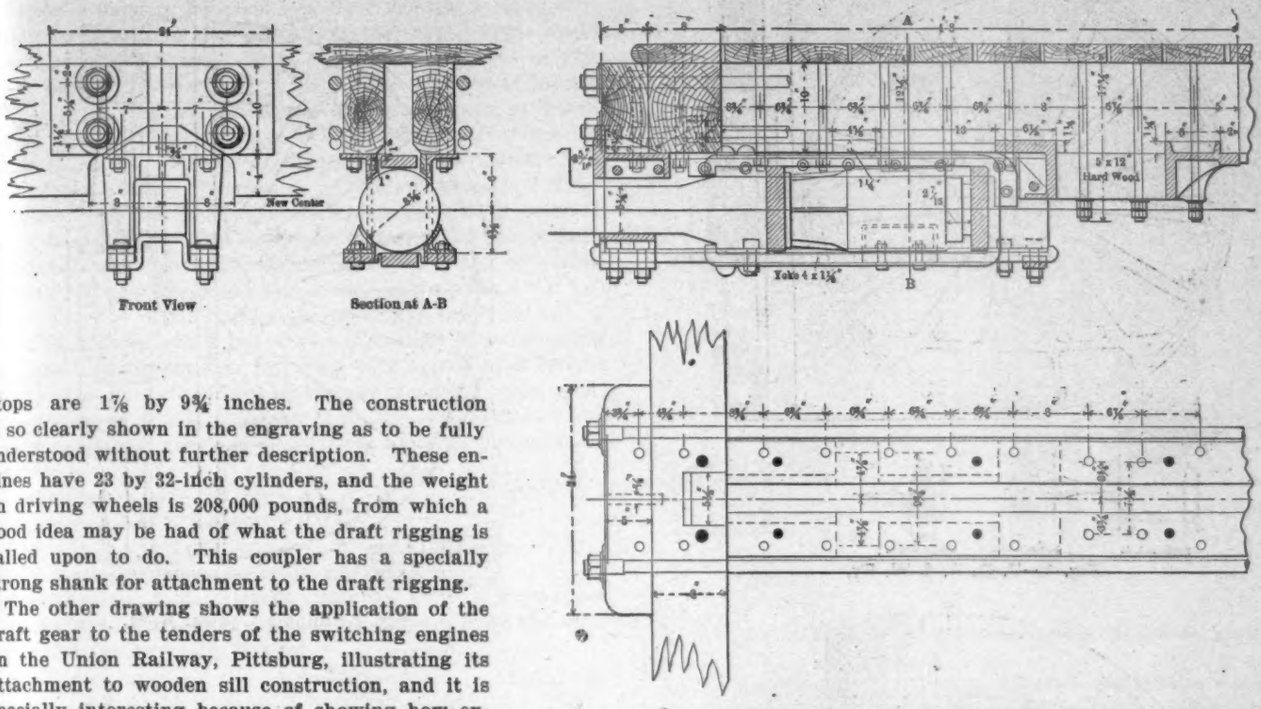
One effect of the use of cars of large capacity and the recent introduction of exceedingly powerful locomotives is to direct attention to the weakness of the draft gear on cars and also on locomotive tenders, which is becoming serious because of the expense of repairs. The relief most naturally sought by railroad men is the increase of spring capacity in the draft rigging; but this, while improving the strength of the gears, introduces what is believed to be a serious difficulty, that of an increased liability of breaking the trains in two on account of the reflex action of these heavy springs when the load, either in tension or compression, is suddenly removed. This occurs in hauling trains out of "sags," and it points toward the desirability of improving the draft-gear capacity in some other way. The ideal plan for very heavy stresses seems to be one which greatly increases the resistance in both pulling and buffing without subjecting the parts to the sudden shocks of greater spring power. This is done by the Westinghouse friction draft gear, which we shall describe in detail in a future issue. This device provides that which has not been accomplished in any other way. It furnishes enough spring power and incidentally takes care of the very heavy stresses which heavier springs do not appear to be well adapted to handle, and it does this without endangering the equipment by excessive recoil.

The very large consolidation locomotives built in 1898 for



Westinghouse Friction Draft Gear,
Applied to Tender with Steel Sills.
Union R. R., Pittsburgh.

the Union Railroad by the Pittsburg Locomotive Works, and illustrated in our issue of November, 1898, page 365, had exceptionally strong tender draft gear, but after running a number of months it was found necessary to substitute the Westinghouse draft gear, as shown in one of our engravings. This is an example of its attachment to steel center sills, which were orginally placed 13½ inches apart, and while not specially designed for its reception, the equipment goes in very nicely. It is held by heavy castings bolted by a number of ⅞-inch bolts to the lower flanges of the large steel channels. This is a very simple and strong arrangement, making use of 20 close-fitting bolts to take the stresses of the stops. The



Westinghouse Friction Draft Gear.
Applied to Tender with Wooden Sills.
Union R. R., Pittsburgh.

stops are 1⅞ by 9¾ inches. The construction is so clearly shown in the engraving as to be fully understood without further description. These engines have 23 by 32-inch cylinders, and the weight on driving wheels is 208,000 pounds, from which a good idea may be had of what the draft rigging is called upon to do. This coupler has a specially strong shank for attachment to the draft rigging.

The other drawing shows the application of the draft gear to the tenders of the switching engines on the Union Railway, Pittsburg, illustrating its attachment to wooden sill construction, and it is specially interesting because of showing how existing wooden structures may be adapted to receive it. In this case the casting containing the friction gear is supported by a cast saddle, which is bolted to the lower flanges of the two 10-inch channels, the webs of which are cut away to receive the barrel. These channels are bolted to the bottom faces of the wooden center sills, as shown in the sectional view. The front view illustrates the substantial carrier casting, which is also shown in the longitudinal section, where its attachment to the end sill is seen. The yoke attachment is of 4 by 1¼-inch iron and the draw-bar stops are unusually large. In the end view the ends of four large through rods are shown. These were used in connection with the draft gear with which the tenders were originally fitted. The lower rods were raised a little over one inch to accommodate the Westinghouse attachment. Attention is directed to the very large keys let into the end sill and the center sills over the draft gear, and to the large bracket castings at the rear of the whole rigging; also to the 5 by 12-inch oak blocks placed between these brackets and secured by bolts to the bottom faces of the center sills. The inner brackets butt against the center plates. The upper flanges of these castings are let into the bottom faces of the sills, and they act as keys 1¼ inches thick to assist in transmitting the stresses to those large timbers. This draft gear was applied to these tenders to obviate serious difficulty in regard to the ordinary gear, which required a large amount of repairs, and since this change there has been no trouble of any kind. The coupler shank is changed somewhat from the usual form to make it stronger where it connects to the yoke. With ordinary devices the coupler is much stronger than the draft gear, while with this equipment the order appears to be reversed.

It is impossible to give at this time exact comparative statements of the cost of maintenance of the Westinghouse friction draft gear with other draft gears because, so far as we know, no record has been kept of the time the equipment has been held idle in the shop for the repairs of the ordinary draft gear to be made. A statement is at hand, however, from a railroad in Pennsylvania, from which it is learned that seven six-wheel connected engines, operating with rigid draft gear on the tenders, showed an actual cost for repairs of the draft gear and end sills of 81 cents per 1,000 miles run; while four engines of exactly the same class, equipped with the Westinghouse friction draft gear, have made a record of 76,800 miles since being thus equipped, without costing anything for repairs of these parts. This is a saving of 81 cents per 1,000 miles, or a total of $62.20 in favor of the friction draft gear in this mileage, which was made in six months, and in very severe service.

On this same road two exceptionally heavy locomotives, put into service some time ago, were fitted with specially strong tender draft gear, designed with reference to the service by the builders, and after running 35,856 miles without expense for repairs it was found necessary to replace the draft rigging with the friction device. These two engines have since made a combined mileage of 23,364 miles with the new gear without any repairs, and the parts now appear to be in as good condition as when the change was made. Some idea of the service may be had when it is stated that these engines are capable of exerting a draw-bar pull of over 50,000 pounds.

A 100,000 HORSE POWER CENTRAL STATION.

The power station of the Third Avenue Railroad of New York is to have the greatest power producing capacity ever assembled in one place. It is now under construction, and according to "Power," the capacities, as far as they have been decided upon, will be as follows:

Boilers, number	60
Boilers, capacity, each, rated	520 H. P.
Boilers, aggregate capacity, rated	31,200 H. P.
Boilers, heating surface	312,000 sq. ft.
Working pressure	200 lbs.
Engines, number	16
Diameter high-pressure cylinder	46 in.
Diameter low-pressure cylinder	86 in.
Revolutions per minute	75
Aggregate area high-pressure pistons	26,590 sq. in.
Aggregate area low-pressure pistons	92,940 sq. in.
Aggregate area both pistons	119,530 sq. in.
Horse power, rated, each	4,500
Horse power, rated, total	72,000
Horse power, maximum, each	7,000
Horse power, maximum, total	112,000
Ratio, maximum to rated	1.56

The plant will have the capacity to carry a sustained load of 100,000 H. P. The consumption of coal will be about 75 tons per hour when running at full capacity. An idea of the engine capacity is given by the statement that if all of the piston area was combined in a single cylinder it would have a diameter of 32½ feet. The contract for the boilers has been closed with the Babcock & Wilcox Co. They will be placed in two stories of the building and provided with automatic coal and ash handling machinery and Roney stokers.

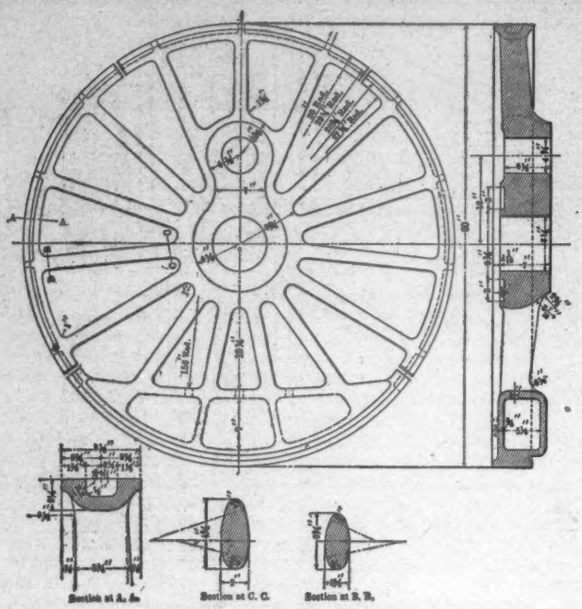


Fig. 1.—D. Q. R. & W. Ry.

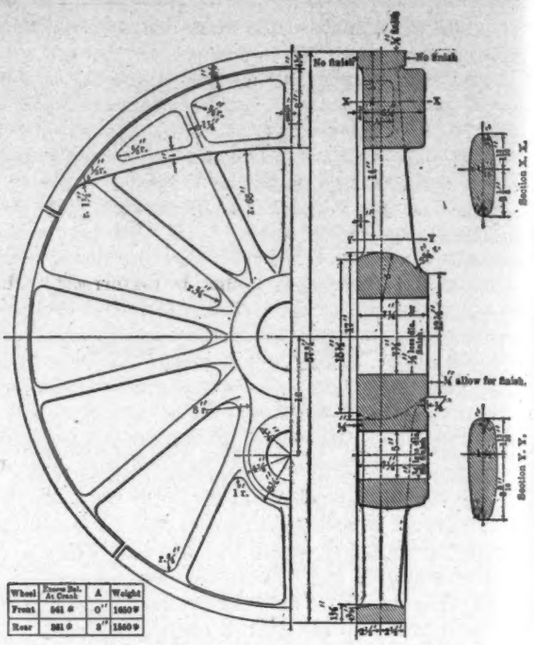


Fig. 2.—Illinois Central R. R.

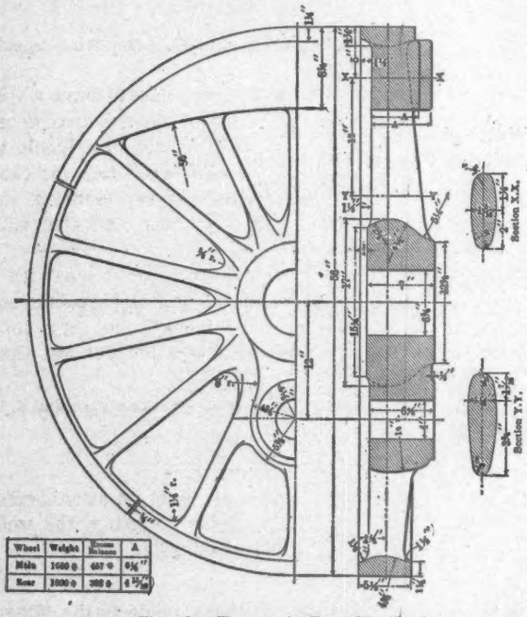


Fig. 3.—Texas & Pacific R. R.
(The weight of the rear wheel is 1,600 lbs., not 1,000, as indicated in the cut.)

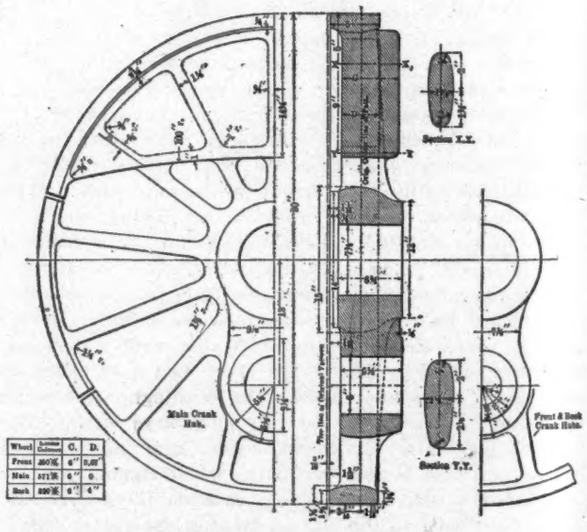


Fig. 4.—Wisconsin Central.

CAST-STEEL DRIVING WHEELS.

Last month we printed a number of drawings of cast-steel driving wheels to show the possibilities of weight saving. The drawings which are now presented bring out other features. They show six designs of cast-steel driving wheels made by the Sargent Company of Chicago for as many different railroads. These range in diameter from 44 to 60 inches, and the weights are given in most of the engravings.

Attention should be directed to the location of the divisions in the rims of cast-steel wheels. These are for the purpose of disposing of the internal stresses in the castings due to the unevenness of section through various parts of the wheel. The rim should be cut on both sides of the spokes running into the crank hub and into the counterweight. The reason for this is clear, but it is not always remembered by the draftsman in designing driving wheels. Wheels have been made successfully without cutting the rims, but it is believed to be safer to cut them.

There are differences of opinion with regard to the best shape of spokes. Some of the locomotive builders, notably the Baldwin and Schenectady, appear to favor the elliptical section, while others, the Brooks, prefer a nearly rectangular form. Both are successfully cast, although the rectangular spoke appears to have been a little more difficult to manage in the foundry at first. The foundrymen now seem to have no preference. As a matter of taste, the rectangular form is more graceful in appearance and it has the important advantage of rendering the parts covered by the driving wheels more accessible. Various forms of spokes are seen in the illustrations of last month, and in the present article, and the light, open appearance of those of rectangular form is very marked.

There is a strong inclination on the part of steel makers toward solid hubs, both for the axle and the crank pin. The form of counterbalance weight shown in Fig. 2, the Illinois Central 57¾-inch wheel, the Wisconsin Central 50-inch wheel, Fig. 4, and the Texas & Pacific 56-inch wheel, Fig. 3, is also strongly advocated. These wheels are made with the counterbalance weights open on one side. If the steel makers receive

the proper information from the railroads, the metal in the counterweights may be calculated very closely, so that very little or no additions need be made in the shops. Some wheel centers are made entirely without counterweights, as in Fig. 5, the Union Pacific wheel. This requires the use of blocks. Other designs require box forms of the castings, in which large cores must be supported, and some require centers with large pockets for the counterweights, with very limited openings for the venting of the cores. These castings are difficult to make on account of the danger of blow holes. For insuring sound castings, the open design is preferred. If box-shaped counterbalances are required, the cores should be vented through large openings in the rim and inside plate.

The question of the steel to be used may safely be left to reputable makers, and it is not wise to hamper them too much with special requirements, although it is a good plan for the purchaser to keep close track of what he is buying. Acid open-hearth steel, with a composition as follows, has been found to give satisfactory results for locomotive parts, including wheel centers:

Carbon, 0.25 to 0.30 per cent.

Manganese, 0.60 to 0.80 per cent.

Silicon, 0.25 to 0.35 per cent.

Sulphur and phosphorus, below 0.04 per cent.

Some time ago the Sargent Company made a comparison between annealed and unannealed pieces cast from the same heat, with the following results:

	Tensile strength lbs. per sq. in.		Elongation in 8 inches.		Reduction of area.	
Spec.	Unann'l'd.	Ann'l'd.	Unann'l'd.	Ann'l'd.	Unann'l'd.	Ann'l'd.
4,530	61,740	60,000	18.5%	25.75%	22.2	51.15
4,531	68,500	67,500	22 %	30 %	26.3	46.25

Chemical Composition.

Specimen.	4,530	4,531
Carbon	0.28%	0.27
Manganese	0.78	0.74
Silicon	0.26	0.29
Sulphur	0.046	0.049
Phosphorus	0.028	0.028

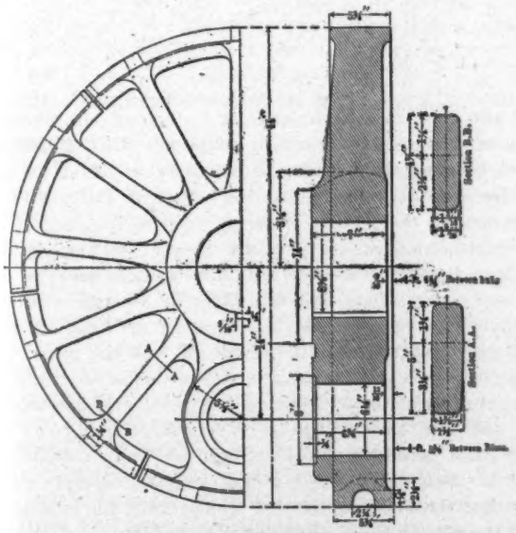


Fig. 5.—Union Pacific Ry.

The fracture of the unannealed specimens was crystalline, which, in the annealing, changed to a silky appearance. This steel, when unannealed, is up to the ordinary specifications, although the reduction of area is rather low. This material is believed to be excellent for wheel centers. As a guide to those who are preparing specifications for cast steel, the following are recommended as having been found satisfactory for driving-wheel centers and other cast-steel parts:

Specifications for Steel Castings.

1. Castings must be true to pattern, sound and solid, free from sand, slag, scale and shrinkage cracks, and all fins and risers must be trimmed off in a workmanlike manner, and the castings have a reasonably smooth surface.

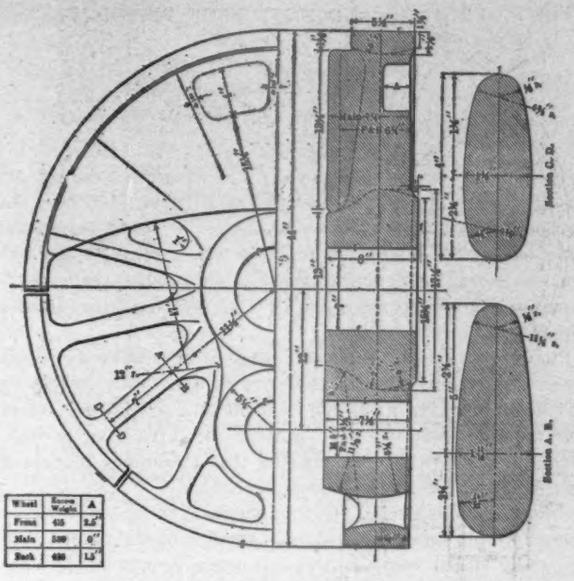


Fig. 6.—C. I. & L. Ry.

2. All castings must be annealed unless otherwise specified.

3. All important and very large castings should have a test coupon attached to them of sufficient size to furnish two pieces for test. For smaller castings, where it is not practicable to attach test coupons, test bars may be cast separately for each heat, and their record will be accepted as representing the metal in the castings, provided they have been annealed with the pieces they represent.

4. A test bar cut from the coupons and turned up with a test section ½ inch in diameter and 2½ inches long between the shoulders, must show a tensile strength not less than 60,000 pounds per square inch, and an elongation not less than 20 per cent. in two inches.

5. All important castings should bear designating mark of the steelmaker.

By far the most handsome calendar yet received at this office for the year 1900 is that of the J. G. Brill Company, the well-known car and truck builders, Philadelphia, Pa.

A munificent gift of $50,000 was recently made to the Massachusetts Institute of Technology by Mr. Augustus Lowell. This gift is to be used in establishing a retiring fund, the income of which is to be given to the teaching staff of the institute in case of illness, death or retirement.

A new lubricated center plate for cars has just been patented by Mr. Clement F. Street, Manager of the Railway Department of the Dayton Malleable Iron Co. It involves no complications whatever, but by its form permits of oiling conveniently and retains the oil indefinitely. When its importance becomes appreciated this device will be in great demand.

A remarkable record was recently made by one of the Schenectady compound locomotives of the Minneapolis, St. Paul & Sault Ste. Marie R. R. Co., on a run between Harvey and Camden Place, a distance of 627 miles. The train pulled by engine 520 consisted of 9 cars of about 39 tons each. The run was made in 12 hours and 5 minutes, including stops. The stops were 55 in number and an average of 7.14 miles per stop. The maximum speed was 67 miles per hour and the average 52 miles per hour. This run is a continuous and regular one for these engines and it is reported that hot driving boxes are practically unknown among them.

PORT OPENINGS AND MOTION OF PISTON VALVES.

By C. A. Seley,

Mechanical Engineer, Norfolk & Western Ry.

The advent of the piston valve in locomotive design brings up the question as to whether there should be any change in the adjustments of the valve motion work from that of slide valves on engines, similar in other respects, but which are equipped with piston valves. It would seem to be a question in which the area of the port opening should be considered.

Piston valves thus far noted have a circumference equal to about twice the length of the port as used with a slide valve, and when working at a short cut-off and partial port opening, give from 50 to 75 per cent. greater port area than is obtained with the slide valve. In making this statement bridges have been allowed for in the piston bushing.

Properly constructed piston valves, being perfectly balanced, do not spring or wear the motion to the extent suffered by their older competitors and adjustments made can be counted upon to last for a much longer time.

The last few years have seen a radical change in opinion regarding full gear lead, and competent authority only recognizes it as a measure by which to obtain proper lead in running positions. There is not so much difference of opinion on the latter point as to amount but more as to the best method of getting it. In Halsey's "Locomotive Link Motion" the methods of a number of leading roads to attain proper lead are given, from which it will be noted that ¼ inch at one-fourth cut-off is recognized by the majority as a standard. With ¼-inch lead and a 16-inch port the area of the opening would be 4 square inches, using a slide valve, while a 10-inch piston valve will give about 6 square inches. This opening begins when the crank is about 20 to 25 degrees from the dead center before the forward stroke of the piston and with a piston travel of, say, 30 inches, the piston has yet about ¾ inch to travel.

Experiments are necessary to determine the point but it is possible that the lead of engines with piston valves may be such as to give less than ¼ inch at one-fourth cut-off with best results in wear of pins, boxes and life of frame bolts and connections. Although there is greater available port opening, yet it must be borne in mind that reduction of lead for a given cut-off reduces also the maximum port opening following. For this reason experiment rather than theory will give the desired information.

Prior to the adjustment of some engines which are to be equipped with piston valves, it was thought desirable to thoroughly investigate the valve motion which has been in use on other engines of the same class using slide valves. The principal dimensions are as follows: Cylinder, 21 by 30 inches; steam ports, 1⅝ inches; steam lap, 1⅛ inches; exhaust lap, line and line; diameter of piston valve, 10 inches; radius of link, 46 inches; offset of link saddle pin, 15/16 inch; link hanger, 18½ inches; eccentric throw, 2½ inches; rocker arms, top 13 inches, bottom 10 inches; main rod, 124 inches.

A valve motion model was rigged, full size, by which all events in the stroke could be noted by crank angles which were subsequently reduced for convenience of reading to inches of stroke of the piston to the nearest ⅛ inch. It had been customary to set these engines, having slide valves, with 1/16-inch lead in full gear, forward and back, and the model was first set in that way.

It was found that the lead at one-fourth cut-off (7½ inches) averaged ⅜ inch, and the distribution was very good. The full gear lead was then changed to line and line with a resulting 5/16-inch lead at one-fourth cut-off and slightly better distribution.

A third setting of 1/16-inch negative lead in full gear forward and back gave an average of ¼-inch at one-fourth cut-off and absolutely equal cut-off at each end. This might be construed by some who desire to equalize cut-off so as to allow for less on one side due to the effect of the piston rod as incorrect, but the results certainly show a fine motion.

A trial was then made of an unequal setting, giving line and line in full gear forward and ⅛-inch negative lead in full back gear. This had the effect of almost equalizing the lead over the range of one-half to one-fourth cut-off, but seriously disturbed the equality of cut-off, and the maximum port opening was no greater than in the previous setting.

The results of these tests are tabulated and presented herewith, the first line across in each setting being the forward stroke, the second the return, and so on, alternately. The offset of the link saddle pin was also tested and the results show that the fine equalization was largely due to this feature when the offset was 15/16 inch. A reduction of offset produced marked inequality with the only redeeming feature of a reduction of slip of the link block.

Analysis of link motion as above described is very interesting and the data secured will be found very valuable, particularly on roads whose custom is to have one fixed full gear lead for all engines, regardless of the length of blades, offset and other details of the motion. The small importance of full gear lead of itself is shown by the fact that to give 1/16-inch movement to the valve in full gear required a crank movement of but 1½ degrees, which is not perceptible in crank effect. Unless eccentric blades are long and full gear lead is necessary to give proper lead in running position of the link, it is absolutely detrimental.

As a matter of interest in connection with piston valves a

Effect of Changes in Full Gear Lead.

1/16 in. Lead in Full Gear Forward and Back.

Gear.	Lead.	Maximum Port Opening.	Port Closed.	Release.	Slip.
Full, forward.	1/16 in.	1⅝ in. in 3¼ in. piston travel.	26¼ in.	29 in.	1 7/16 in.
" "	1/16	1⅝ " 3 " " .	26	28¾	
" back....	1/16	1⅝ " 3⅝ " " .	26¼	29	1 7/16
" "	1/16	1⅝ " 3⅛ " " .	26+	28⅞	
⅛ cut-off, Fd.	5/16	1/16 " 2¾ " " .	14¾	23¾	
⅛ " " .	1/32	3/32 " 3 " " .	15¼	24	3/32
¼ " " .	1/32	3/32 " ¾ " " .	7⅝	19	
¼ " " .	1/32	3/32 " 1 " " .	7⅜	19⅜	3/32

Lead Line and Line in Full Gear Forward and Back.

Full, forward.	0	1⅝ in. in 3¼ in. piston travel.	26 in.	29 in.	Same slip in similar gears as above.
" "	0	1⅝ " 3⅛ " " .	26⅜	29	
" back....	0	1⅝ " 3⅛ " " .	26⅛	29⅛	
" "	0	1⅝ " 3⅜ " " .	26⅜	29	
⅛ cut-off, Fd.	3/32 in.	1/32+ " 3¼ " " .	14¾	24	
⅛ " " .	3/32—	1/32 " 3⅛ " " .	15¼	24¼	
¼ " " .	1/32	1/32 " ¾ " " .	7⅝—	19⅜	
¼ " " .	3/32	1/32 " ¾ " " .	7⅜+	20	

1/16 in. Negative Lead in Full Gear, Forward and Back.

Full, forward.	−1/16 in.	1⅝ in. in 3¾ in. piston travel.	26¼ in.	29⅛ in.	Same as above.
" "	−1/16	1⅝ " 3⅛ " " .	26⅛	29⅛	
" back....	−1/16	1⅝ " 4¼ " " .	26¾	29¼	
" "	−1/16	1⅝ " 4 " " .	26⅛	29¼	
⅛ cut-off, Fd.	3/32	1/16 " 3¼ " " .	14¾	24⅜	
⅛ " " .	3/16+	3/16 " 3¾ " " .	15¼	24⅛	
¼ " " .	¼+	1/32— " ¾ " " .	7½	20	
¼ " " .	¼—	3/32+ " ⅞ " " .	7½	20⅛	

Lead, Line and Line, Full Gear Forward, ⅛ in. Negative Full Back.

Full, forward.	0	1⅝ in. in 3¼ in piston travel.	26 in.	29 in.
" "	0	1⅝ " 3⅛ " " .	26⅜	29
" back....	−⅛ in.	1⅝ " 4⅛ " " .	26⅞	29¼
" "	−⅛	1⅝ " 4⅛ " " .	26¾	29¼
⅛ cut-off, Fd.	¼	1/16 " 3⅛ " " .	14⅛	24
⅛ " " .	¼	5/16— " 4 " " .	15⅛	24⅛
¼ " " .	¼+	1/16 " 1⅜ " " .	7	19⅝
¼ " " .	¼+	1/16+ " ¾ " " .	8	20⅛

Influence of Change in Off-set of Link Saddle Pin.

Lead 1/16 in. Negative in Full Gear, Forward and Back.

	½ Cut-off.			¼ Cut-off.		
Off-set.	Port Closed.	Release.	Slip.	Port Closed.	Release.	Slip.
1/16 in.	14¾ in.	21⅜ in	3/32 in.	7⅛ in.	20 in.	3/32 in.
	15¾	21⅛		7⅛	20⅛	
1/8	14⅛	21⅛	3/32	7¼	19¾	1/16+
	15⅛	21⅛		7¾	20¾	
1/16	14¼	21	1/32	7	19⅛	1/32
	15¾	21¾		8	21	
	13¾	23⅞	1/32	6¾	19¼	1/32
1/16	16¼	21¾		8⅜	21⅛	
	13⅛	23⅞	1/32	6⅝	19	3/16−
1/16	16⅛	24⅞		9	21⅜	

Port Opening Areas.

	Slide Valve.		Piston Valve.	
Lead in Full Gear.	Lead Opening.	Maximum Opening.	Lead Opening.	Maximum Opening.
	One half cut off.		One-half cut off.	
1/16 in. positive lead. ..	5¾ sq. in.	10¾ sq. in.	8.37 sq. in.	15.58 sq. in.
Line and line...	4½ "	9½ "	6.5 "	13.75 "
1/16 in. negative lead ..	3¼ "	9 "	4.71 "	13.08 "
	One fourth cut-off.		One-fourth cut-off.	
1/16 in. positive lead...	6 sq. in.	7 sq. in.	8.72 sq. in.	10.47 sq. in.
Line and line....	5 "	6 "	7.26 "	8.72 "
1/16 in. negative lead..	4 "	5 "	5.81 "	7.3 "

Note.—The above areas are calculated from a 16 in. steam port with slide valve and from a 10 in. piston valve deducting 8¼ in. for bridges.

table is presented giving the lead opening areas and the maximum port areas at one-half and one-fourth cut-off for the three settings above described, calculated for both slide and piston valves used with these engines. The advantage of the piston valve is readily seen, and when we consider that these openings will be maintained much longer by reason of less spring and wear of the piston valve motion, the argument would seem to be greatly in its favor.

NEW MONARCH PISTON AIR DRILL.

The accompanying engraving illustrates a pneumatic drill which is built with a solid tool-steel three-way crank, hardened at the various bearings and made ball-bearing throughout the drill. The pinions are made of tool steel. The piston-crank connections and end bearings of the crank are each provided with two sets of ball races. The engine part is entirely separate from the spindle. The makers claim this as a great advantage over other drills, on the ground that any undue strain put on the spindle cannot in any way affect the working part of the engine. The gears and pinions are also separate from the engine and are well protected against dust and dirt. The reversing throttle and starting throttle are all in one. In order to reverse the machine all that is necessary is to turn the throttle past the inlet ports and make connection with the ports that act as exhaust ports while the machine is running forward. This drill is also provided with a small lock, so that it can be made to run only in one direction when desired. This drill measures but 12 inches from the end of the spindle to the screw and it can be used within 2½ inches of a corner. Its weight is only 18 pounds and it will drill any size hole up to 1¾ inches in diameter. It has a feed-screw length of 4 inches. One of the most desirable features about this drill is that it is specially adapted for boiler work. It is reversible and can be used for tapping staybolts, running them in or out, and, in fact, can be used for any purpose where a reversible drill is desired. It is provided with a handle and standard ½-inch socket for machine bits, which will allow it to be readily converted into a wood-boring machine whenever desired.

The Standard Railway Equipment Company, makers of this

Monarch No. 4 Piston Air Drill.

new drill, claim economy in the consumption of air and simplicity in the mechanical construction. This drill will be furnished to any one desiring to give it a trial; also catalogues showing their Monarch tools may be had by addressing either the St. Louis, Chicago or New York offices.

LUCOL OIL AND PAINTS.

Lucol is an oil which has been used for painting purposes during the last ten years in various parts of the United States. It is prepared, like linseed oil, both boiled and raw, and it is especially suitable for painting and is held to be superior to linseed oil in many respects, but it has not yet been found adaptable to the manufacture of varnishes, for which large quantities of linseed oil are used.

It is a manufactured oil, built upon a base entirely different from linseed oil. Animal fats and oils consist of olein, margarine and stearine. The olein is extracted, and after being carefully refined is used as a base for the manufacture of lucol, which, when completely matured, is a brilliant transparent oil. The manufacturers state that the oil owes its "life" to the gum, which oxidizes out of it when mixed with pigments and used as a paint. This corresponds to the linseed-oil gum, but offers greater resistance to the destructive agencies in the air and to gases which may be present in the air. This material was developed on the Pacific Coast, the first factory being at Stege, Cal. It was subjected to very varying climatic conditions, such as those of Alaska, California, Arizona and the Hawaiian Islands. It is now manufactured at Carteret, N. J., and the development of the business and the demands for lucol have been rapid, especially during the recent period of depression.

The manufacture of lucol paint was commenced three years ago and it has already become necessary to enlarge the paint department a second time. While there is said to be no danger of spontaneous combustion with lucol, it has been deemed advisable to provide a fire-proof building of iron and concrete for the paint department, the object of this precaution being to insure against delays in supplying the demand.

The American Lucol Company manufactures paints for many different purposes. These include carbon, graphite, iron oxide, red lead and lead-zinc paints in all tints. The advantages claimed for these paints are good covering qualities, ability to retain glo. and original tints for a long time, good filling qualities for brick and wood, the absence of blistering, peeling and scaling, and elasticity, with high resistance to moisture, salt air and fumes of acids and chemicals.

There has been a controversy over the question of the best paint for the protection of iron work, and with the constantly increasing number of important metallic structures an adequate protection for their surfaces is correspondingly important. These manufacturers mix pure red lead with lucol for this purpose, making a pure red-lead paint and red-lead paste. This cannot be done satisfactorily with linseed oil, and many engineers and architects have been obliged to give up the use of red lead as a protective coating for iron for this reason.

The lucol red-lead paint has been named the "Red Dragon Brand." It is stated to be easily stirred up and made ready for use, to which is added the most important attribute of durability. Another paint, called "Telemet," is a carbon paint for structural iron, which is very elastic and durable. This concern manufactures the Lucol Spraying Paint, of which many railroad men speak in high terms. It is mentioned elsewhere in this issue in connection with the Columbus, Hocking Valley & Toledo Railroad. It is understood that but one coat of this spraying paint is required and that cars sprayed with it may be lettered on the same day, necessitating only about 12 hours' delay. Attempts have been made to produce such results by the use of dryers, but this seriously affects the durability of the paint.

In our August issue, 1898, page 259, we printed the test record of paints on the 155th Street steel viaduct in New York in which Mr. Henry B. Seaman places Lucol paint as second in a test of 17 paints for the most severe service imaginable.

The company is busy with its home trade, but the demand has already extended abroad, and we are informed that more than a car load of lucol paint was recently shipped to British India. There are probably no more conservative men to deal with in regard to paints than architects and engineers and steamship owners. Many of these have adopted this material exclusively, and this has been done as a result of tests made with linseed-oil paints. The Chief Engineer of the Brooklyn Bridge adopted this paint after a six years' trial of thirty barrels of lucol, which was compared in severe exposures with linseed oil and the same pigments. The train sheds of the Boston Southern Terminal and three of the four bridges across the Niagara River are painted with it. On one railroad where the first trials were made ten years ago, 25 car loads have been used for stations, bridges and cars during the last two years.

The American Lucol Company was organized ten years ago with a capital of $1,000,000, of which one-half is cash. The incorporators were those who fully understood the increased life of lucol over linseed oil, and the success of the company is due in a large measure to this fact.

PERSONALS.

Mr. C. N. Sanders has been appointed Chemist of the Norfolk & Western, vice Mr. W. W. Davis resigned.

Mr. Berian Warren, Master Mechanic and Purchasing Agent of the Toledo, Peoria & Western, has resigned and will retire from active railway service after a continuous and successful service of 48 years.

Mr. Charles Blackwell, who is well known to our readers, has been appointed Chief Engineer of the Wheeling & Lake Erie R. R. to succeed Mr. F. E. Bissell, who has resigned to accept service with another company.

Mr. Joseph Billingham, Master Mechanic of the Wheeling division of the Baltimore & Ohio, has been appointed Master Mechanic of the second, third, fourth and fifth divisions also, with headquarters at Cumberland.

Mr. Edward Grafstrom has resigned from his position with the Pennsylvania Lines at Columbus, Ohio, and has been appointed Mechanical Engineer of the Illinois Central Railroad, to succeed Mr. W. H. V. Rosing, promoted.

Mr. John T. Wheeler, formerly in the Purchasing Department of the Grand Rapids & Indiana, at Grand Rapids, Mich., has been appointed Purchasing Agent of the Sargent Company at Chicago, with office at 675 Old Colony Building.

Mr. M. E. Ingalls retired from the Presidency of the Chesapeake & Ohio on February 1, but continues as President of the Cleveland, Cincinnati, Chicago & St. Louis. He has been President of the Chesapeake & Ohio since October 1, 1888.

Mr. S. E. Dickerson has been appointed Master Mechanic of the Lake Shore & Michigan Southern at Norwalk, O., vice Mr. J. O. Braden, transferred. Mr. Dickerson was formerly in the mechanical department of the Norfolk & Western.

Mr. J. E. Battye has been appointed Division Master Mechanic of the Eastern General Division of the Norfolk & Western, vice Mr. R. P. C. Sanderson, who recently resigned, to become Assistant Superintendent of Machinery of the Atchison, Topeka & Santa Fe.

Mr. H. M. Pflager has been appointed Mechanical Superintendent of the Pullman Palace Car Co. He has been connected with this company for a number of years in various positions, of responsibility, and was promoted from that of Chief Mechanical Inspector.

Mr. R. F. Hoffman has been appointed Mechanical Engineer of the Atchison, Topeka & Santa Fe System, with headquarters at Topeka. He was connected with the editorial staff of the "Railway and Engineering Review" and two years ago he entered the services of the Santa Fe System. He has had a wide practical experience, having risen from apprenticeship.

Mr. Charles E. Morrill, who has been elected President of Valentine & Co., has been connected with that concern for nearly 40 years. He has had a prominent part in the development of the success of the company, and now takes the place of Mr. H. C. Valentine, who has retired from the presidency to become chairman of the board. Mr. Morrill will divide his time between the New York and Chicago offices.

Mr. Geo. W. Stevens, General Manager of the Chesapeake & Ohio, has been made President of that road, vice Mr. M. E. Ingalls, resigned. Mr. Stevens has been in railroad service since 1864, during which time he has been 6 years with the Baltimore & Ohio, 3 years with Pittsburg, Cincinnati & St. Louis, 17 years with the Wabash, working through several responsible positions to that of Assistant General Superintendent. He went to the Chesapeake & Ohio on January 1, 1890, as General Superintendent, and since July, 1891, has been General Manager.

Mr. E. D. Bronner, heretofore Assistant Superintendent of Motive Power and Equipment of the Michigan Central, has been appointed Superintendent of Motive Power and Equipment of that road, to succeed Mr. Robert Miller, resigned. Mr. Bronner entered the service of the Canada Southern in 1880 as draftsman in the car department. From February, 1883, to April, 1886, he was draftsman in the car shops of the Michigan Central at Detroit, and was then General Foreman of the same shops until 1890, when he was appointed Master Car Builder, which position he filled until May 1, 1896, when he was made Assistant Superintendent of Motive Power.

Mr. Robert Miller, Superintendent of Motive Power and Equipment of the Michigan Central and one of the best-known railroad men in the country, has tendered his resignation after a service of more than 35 years. Mr. Miller's career dates from 1859, and is as follows: From 1859 to 1862, journeyman in the car shops of the Chicago, Burlington & Quincy; 1862 to 1865, in the army; 1865 to 1876, Foreman erecting shops, Chicago, Burlington & Quincy; 1876 to 1884, Master Car Builder, in charge of cars and buildings and water-works, Michigan Central; 1884 to 1890, Assistant General Superintendent of the same road. In 1890 he was made General Superintendent, which position he held until 1896, when he was made Superintendent of Motive Power and Equipment.

Mr. R. P. C. Sanderson, Master Mechanic of the Norfolk & Western, has been appointed Assistant Superintendent of Ma-

chinery of the Atchinson Topeka & Sante Fe, vice Mr. G. A. Hancock resigned. He will make his headquarters at Topeka, and will have more extensive authority than that vested with Mr. Hancock. Mr. Sanderson began railway service in 1882 as draftsman on the Norfolk & Western, and has worked his way up through many responsible positions. In 1891 he was appointed Superintendent of Motive Power of the western general division of the same road. In February, 1895, he was placed in charge of maintenance of locomotives and cars for the entire line and later was made Master Mechanic at Roanoke, which position he has filled up to the time of his new appointment.

Dr. James H. Smart, President of Purdue University at Lafayette, Ind., died February 21. He had been President of the University since 1883. He was born at Center Harbor, N. H., June 30, 1841. He held a degree of A. M. from Dartmouth and LL. D. from the University of Indiana. He attended the Vienna Exposition in 1872 as Assistant Commissioner from Indiana and was United States Commissioner to Paris Exposition in 1878. At the Agricultural Congress at The Hague in 1891 he represented the United States as a Commissioner from the Department of Agriculture. He was elected President of the Indiana Teachers' Association in 1871, and in 1880 held a similar office in the National Educational Association; was also President of the American Association of Agricultural Colleges and Experiment Stations in 1890. His life work was the development of Purdue University, which is a magnificent monument to his ability, energy and self-forgetfulness.

Edwin N. Lewis, Manager of the Railway List Company of Chicago, died at his home in Chicago, February 16, of heart trouble after a brief illness. He was an unusually interesting man, a warm and valued friend to those who had the privilege of knowing him well and he will be missed also by a very large number who enjoyed his acquaintance. Those who met him occasionally found pleasure and profit in his company, because he commanded a large amount of information and was always ready to contribute it in a delightful way. He was earnest, sincere and honest. He had a very convincing way of presenting his arguments, he was a hard worker and stood in closer and more intimate friendly relations with business men than any other man in his line of work. Mr. Lewis was born in Madison County, New York, September 12, 1837. He was educated in Fowler Institute, Newark, Illinois; Knox College, Galesburg, Illinois; Beloit College, Beloit, Wis., and Chicago Theological Seminary, Chicago. After completing his education he was a Congregational pastor and afterward studied law in the office of Cook & Glover. Mr. Cook, of this firm, was later general solicitor of the Chicago Northwestern Ry. and Mr. Lewis succeeded to his practice, which drifted into railroad litigation and especially right of way work. After this he took up newspaper writing on the staff of the "Railway Age," and was instrumental in the success of the Railway Exposition of 1883. He became Manager of the "Railway Purchasing Agent" in 1885 and remained with this publication (which changed its name in 1886 to the "Railway Master Mechanic"), also Manager of the "Official Railway List" up to the time of his death. He read a great deal and was a clear and forcible writer.

BOOKS AND PAMPHLETS.

Master Car and Locomotive Painters' Association. Proceedings of the 30th Annual Convention. Held at Philadelphia September, 1899. Published for the Association by the Railroad Car Journal, New York, 1899.

This volume contains the official proceedings of the recent convention, the constitution, rules and names of members with their positions and addresses. It is well printed and bound.

"The Contractor." The first number of this publication has appeared. It is a fortnightly review of work in the field of construction, dredging, bridge building and engineering operations and contains information concerning proposed work of these kinds. It is not confined to any special line of construction, but railroad work predominates. In the railroad items the length of the proposed lines is given first, which is one of the minor features which helps the reader. It is edited by Walter D. Crosman, and published by the Crandall & Bagnall Publishing Co., 1305 Manhattan Building, Chicago.

"Round the World by Way of New York and Niagara Falls in Sixty to Eighty Days," is the title of a large and handsome folder and railroad map of the United States issued as No. 21 of the Four Track Series by the New York Central & Hudson River R. R. It will be sent on receipt of three cents in stamps by George H. Daniels, General Passenger Agent, Grand Central Station, N. Y.

A pamphlet illustrating and briefly describing a new line of air compressors has just been issued by the New York Air Compressor Company, with works recently established at Arlington, N. J., for the manufacture of simple and duplex direct steam driven or belt driven compressors to meet all requirements of users of pneumatic power. These compressors have been designed with special reference to simplicity, economical service and utmost durability in working parts and absolutely self controlling features. The pamphlet also gives a detailed description of their vertical belt air compressors and gas or gasoline actuated air compressors, which are specialties of these builders.

Ten years ago a technically educated young man did not have the high standing among practical men that now enjoys. He is sought after to-day. The increased demand for men who can operate our mechanisms with less loss than before and effect savings in dollars and cents are the men the large manufacturing and engineering concerns are looking for, and these are the men with a technical foundation. This increasing demand is very interestingly shown by the new catalogue of the Massachusetts Institute of Technology, which is a volume of 360 pages, of which nearly one-third are occupied by the register of graduates and their professional occupations. Also the effect of the growth of the institute in numbers and the very rapid growth in the number of responsible positions in which each years graduates are found is exceedingly interesting. The catalogue also gives the character and quality of the work of the Institute, which is of a high character and worthy of commendation.

Machine Tools.—A very neat catalogue of machine tools has just been issued by the Hilles & Jones Company, Wilmington, Del. This catalogue, No. 6, is 9 inches square, bound in cloth, with 135 pages of illustrations. Those who are familiar with the No. 5 catalogue of this company, which was issued in 1893, will note many changes in their standard patterns which were found necessary in order to meet the continued demand for heavier and more effective machinery. Among the tools of very large capacity which are illustrated and very briefly described in this catalogue are punches and shears, I beams and channel coping and notching machines, plate bending and flanging rolls, vertical milling machines and other standard machines and tools. The illustrations and press work are of a very high order. The descriptions are clear and concise.

Automatic Machinery Catalogue.—The Spencer Automatic Machine Screw Co., of Hartford, Conn., have issued an excellent illustrated catalogue of their automatic machines and the work which may be done upon them. The machines are built in three sizes and in two styles, double and single turret. With these sizes and styles a great variety of work is provided for and the name of the concern, carrying with it the standing gained by twenty years of experience in the field, renders it entirely unnecessary to speak of the qualities of design and workmanship. With the double turret machines work may be done upon both ends of a piece at the same time, and the operations may be carried on as quickly as one. Special provision has been made to secure the turrets rigidly for the sake of accuracy. Six very fine engravings of the machines are shown, and upon the pages facing them are the characteristics of each given in English and metric measures. In other engravings the tools employed and illustrations of the work done by the machines are shown, full size. The pamphlet contains directions for arranging the machines upon the floor to the best

advantage and also the best method of belting to the counter shaft. This is commended as an excellent catalogue. It gives all necessary information about the machines in a few words, and the engravings are selected and executed with noteworthy skill of which the interesting and valuable machine is thoroughly worthy. Our readers who have not investigated these machines should lose no time in doing so, particularly for the small iron and brass work of which the large railroads have a great deal. They are specially adapted to the manufacture of screws, set screws and studs.

"The School of Mechanical Engineering." The International Correspondence Schools of Scranton, Pa., have issued a pamphlet bearing this title. It contains information with regard to the courses of the school in mechanical engineering, mechanical drawing, gas engines, refrigeration and machinery, and will give the information concerning the schools which is desired by those who are considering taking up this form of education.

A New Industrial Situation.—This is the title of a very attractive pamphlet received from the Westinghouse Companies, presenting what is truly a new situation brought about by the introduction of the gas engine into the electric lighting and railway fields. It has an introduction by Mr. Geo. Westinghouse, calling attention to the present wide interest and recent improvements in the generation and distribution of power. He says that long familiarity with the electrical industry, the pipe line transportation of natural gas in great quantities, and an active interest in the development of large gas engines, satisfy him that the economies which will result from the distribution of power by means of gas generated at central points, and conveyed in pipes along the lines of railway, for the operation of engines and electric generators, will be sufficient to justify the expenditure of the capital necessary for such installations in connection with the electrical equipment of railways, particularly metropolitan and suburban lines. The Westinghouse Companies have brought to a high state of perfection all the requisite machinery for the commercially successful operation of standard railways upon which trains are frequent. Mr. Westinghouse states that the advantages of the use of gas engines can be best appreciated when it is understood that if a gas company were to supplant the present gas illumination by an equal amount of electric light, obtained from gas driven dynamos, it would have left for sale, for other purposes, over 60 per cent. of its present gas output. The pamphlet gives the place of the gas engine in the new industrial situation, which in its present development, offers a regulation of speed and smoothness of working equal to the best steam engine on the market. It has been demonstrated that engines of large power up to 650 horse-power are entirely successful and at present two 1,500 horse-power engines are under construction. The pamphlet hints at methods for producing gas at an extraordinarily low cost, as being an expectation of the near future. This statement is made after long and carefully conducted experiments, which the Westinghouse people consider justifies the belief that within a short time gas will be produced commercially and sold at a cost far below the lowest price that now prevails in any part of the world. This expectation realized will constitute a new industrial situation, the full meaning of which cannot now be realized, and the accomplishments of the Westinghouse Companies have been such as to justify faith in the prediction as not being too sanguine. Given cheaper gas, the gas engine at once will take a foremost place. The pamphlet includes a number of engravings of Westinghouse gas engines, applied to lighting and power production and describes a number of successful examples. On reading this pamphlet, the conclusion is forced that there is a great deal back of it, because, as stated in the opening paragraph, "Engineers the world over have long recognized the fact that gas, if supplied at a practical cost, conveyed economically over long distances, and utilized in a form of engine, which should, in speed regulation and smoothness of working, equal the best steam engine, would be the ideal fuel." When such a man as Mr. Westinghouse makes a promise of this kind, fulfilment may be expected.

EQUIPMENT AND MANUFACTURING NOTES.

The Gilman-Brown emergency knuckle, which we illustrated last year, is making satisfactory progress. This device is used in emergency repairs to replace coupler knuckles of various makes and is carried in the cabooses of freight trains. Its form permits of using it temporarily in place of the knuckle of almost any of the couplers now in use. It is manufactured and sold by the Railway Appliance Co., Old Colony Building, Chicago. Five hundred have recently been supplied to the Northern Pacific.

The Cling-Surface Manufacturing Co., of Buffalo, N. Y., has been incorporated under the laws of the State of New York, retaining its former name, with Albert B. Young as president and general manager and William D. Young, vice-president and secretary. The company states that the past year has been the most prosperous in its history, and that the demand for "Cling Surface" is steadily increasing. Branches have been established in Boston, New York and Chicago, while others will be opened soon in St. Louis and New Orleans. W. J. Moxham & Co. importers, Sidney, Australia, have placed a large order and will have the exclusive right to handle it in Australia.

The American Machinery & Trading Co., with chief office in the Bowling Green Building, New York, is prepared to furnish at most favorable prices all lines of high-class factory, mill, electric and power plant machinery, and invites plans and specifications giving date of required delivery. This company will accept agencies from manufacturers for the sale of first-class machinery in foreign countries. An idea of the scope of the concern is given by the following list of branch offices: Chicago, Boston, Philadelphia, Pittsburg, Atlanta, St. Louis, San Francisco, Montreal, London, Paris, Berlin, St. Petersburg and Sydney.

A patent was recently granted Mr. C. W. Sherburne, of the Automatic Track-Sanding Company of Boston, for a new port in the Westinghouse engineer's brake valve, which may be connected at a trifling expense to the air track sanding apparatus, of any manufacture, on the locomotive, thereby insuring automatic flowing of the sand when emergency application is made. This is a specially desirable feature, as all brake experts testify that every part of the brake equipment should be applied by one motion only. This style of engine valve will be furnished by the Westinghouse Air Brake Company when requested.

The Rhode Island Locomotive Works have received orders for 5 consolidation and 3 ten-wheel passenger locomotives for the Colorado & Southern Ry. and for 5 ten-wheel passenger engines for the Fort Worth & Denver City Railroad. The 5 consolidation engines will have cylinders 21 by 28 inches, driving wheels 56 inches in diameter, they will weigh 166,000 pounds, with 148,000 pounds on the driving wheels. The boilers will be of the straight top type with radial stay fireboxes and will carry a working pressure of 190 pounds. The tubes will be 13 feet 6 inches long and 2 inches diameter; the firebox will be 114 by 41¼ inches. The capacity of the tank for water will be 5,500 gallons and the coal capacity 10 tons. These engines will have staybolts of Ulster special staybolt iron, main driving boxes of cast steel, Latrobe tires, Monitor injectors, Nathan lubricators, Standard couplers, magnesia sectional lagging, the Leach sanding device and Sargent combination brakeshoes. The ten-wheel passenger engines for the Colorado & Southern will have cylinders 20 by 26 inches, driving wheels 63 inches in diameter; they will weigh 152,000 pounds, with 118,000 pounds on the drivers. The boiler will be of the extended wagon top type with radial stays, carrying a working pressure of 200 pounds. The tubes will be 13 feet 4 inches long and 2 inches diameter. The firebox 120 by 42 inches. The tank capacity for water will be 5,500 gallons and the coal capacity 10 tons. These engines will have Ulster special staybolts, cast steel driving wheel centers, cast steel main driving boxes, Latrobe tires, Monitor injectors, Nathan lubricators, Magnesia sectional lagging, Leach's sanders and Sargent combination brakeshoes. The 5 ten-wheel passenger locomotives for the Forth Worth & Denver City will have 20 by 26-inch cylinders, 63-inch driving wheels, and will weigh the same as the engines of the same type for the Colorado & Southern. The special equipment and general features of the design of the ten-wheelers for both roads will be practically the same.

CHIEF CLERK WANTED.

Motive Power Department.

A good chief clerk is wanted for the motive power department of a large road in the Middle West, salary $1,800 per year. Executive ability and familiarity with locomotive and car matters are required. Address the Editor of the American Engineer and Railroad Journal.